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A Summary of Current Program 10/1/64

and Preliminary Report of Progress

for 10/1/63 to 9/30/64

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MARKET QUALITY

RESEARCH DIVISION

of the

✓✓
AGRICULTURAL RESEARCH SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE

and related work of the

STATE AGRICULTURAL EXPERIMENT STATIONS

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CURRENT SERIAL RECORDS

This progress report is primarily a tool for use of scientists and administrators in program coordination, development and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of progress on USDA and cooperative research include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of USDA and cooperative research issued between October 1, 1963, and September 30, 1964. Current agricultural research findings are also published in the monthly USDA publication, Agricultural Research. This progress report was compiled in the Market Quality Research Division, Agricultural Research Service, U. S. Department of Agriculture, Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

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INTRODUCTION

Market Quality research deals with the measurement, improvement, and protection of the quality of agricultural commodities in marketing channels. The work encompasses physiological, biochemical, pathological, and entomological problems encountered during the storage, transport and distribution of agricultural commodities, and the development of new methods and devices for evaluation of quality.

The Market Quality Research Division is a part of the Agricultural Research Service. It is headquartered at Hyattsville, Maryland. The greatest concentration of its scientific personnel is at Beltsville, Maryland. Here the Instrumentation Research Laboratory, the Post-Harvest Pioneering Research Laboratory, and field stations of the Field Crops and Animal Products Branch, and the Horticultural Crops Branch are located. Additional personnel are located in Washington, D. C. There are also 20 field stations located throughout the country including two Terminal Market Laboratories; eight of these are located at State Universities or branch Experiment Stations. Total research effort including research contracts amounts to approximately 150 professional man years.

Although a large variety of excellent quality fresh agricultural products are retailed at reasonable prices throughout the year there is need for further research on methods to reduce spoilage and waste during storage, transportation and distribution and to improve methods for evaluation of quality. Stored product insects and market diseases still take heavy tolls of some lots of produce. Also there is urgent need for new methods of control that will not create health hazards due to pesticide residues. There is increasing need for automated objective methods of quality evaluation to make possible rapid reliable grading and inspection of large quantities of produce under modern packing and handling conditions.

As might be expected an appreciable amount of Market Quality research is related to the effective performance of the Service Divisions of the Agricultural Marketing Service responsible for standardization, inspection, and grading of agricultural commodities. The Division also works closely with industry and other Government Agencies on various problems relating to agricultural commodities in the marketing channels. Specific examples of Market Quality research accomplishments over the past five years are:

New Treatment for Insect Control in Food Warehouses. Extensive research has been completed on the development of dichlorvos as a warehouse treatment to prevent insect damage to stored products. Special application equipment was constructed and patent rights are being investigated. A weekly application of as little as one-twentieth of an ounce of material to each 1,000 cubic feet gives effective protection under many storage conditions. The residue is not long lasting and repeated applications left less than 1 part per million of residue in packaged foods. The residue data are being presented to the Food and Drug Administration in a petition for a tolerance.

Heat Treatment for Control of Decay of Fresh Fruits and Vegetables. Although heat has been used to a limited extent to control certain plant diseases for many years, the recent concern regarding chemicals in foods has stimulated research with heat as a method of decay control. Following promising results obtained by the Department with hot water treatment of peaches (published in MRR 643) one large peach grower in Georgia successfully treated his entire crop in 1964. A very large packing house in South Carolina has also installed a heat-treating tank in the packing line. There is also a successful commercial application in Florida of the hot water treatment for the control of anthracnose decay of mangos. Promising results are being obtained experimentally with hot water for control of decay of bell peppers and citrus fruits and with hot air for control of decays of strawberries, red raspberries, and blueberries.

Development of a Pneumatic Probe Sampler. A pneumatic probe sampler was developed for the specific purpose of sampling grain stored in deep bins. It has demonstrated the ability to draw samples from these lower limits and has detected damage or insect infestation existing at floor levels in bins of corn believed to be in perfect condition. The pneumatic sampler also is the only known device found capable of drawing a sample from any location within grain transported by railroad in the new 100-ton capacity covered hopper cars. ASCS and the Grain Division, AMS, have contracted for the manufacture of a number of these devices.

Irradiation. Placement of a mobile gamma irradiator at the Fresno field laboratory during the past fiscal year enabled evaluation of this treatment for a wide range of horticultural crops, field crops, meats, poultry, and stored product insects under semi-commercial conditions. Postharvest decay reduction, without serious adverse effects on the quality of the commodity, was obtained with fresh strawberries, nectarines, figs, and mushrooms. Most of the other horticultural commodities treated showed adverse effects on texture, color, or flavor at irradiation dosages producing worthwhile decay reduction. With this information producers and shippers of horticultural crops can better assess the commercial possibilities of the irradiation treatment. There was a significant initial loss in sedimentation values

of wheat with increasing levels of radiation. Germination percentages decreased at dosages above 25 krads. At 125 and 175 krads distinct off odors were evident in the hot breads. The shelf-life of tray-packed cut-up chicken was extended to 23 to 25 days by irradiation when subsequently stored at 34° and at 40° F., compared to 11 days for the nonirradiated controls. Dosage required for sterility or mortality of insects ranged from 10 krad to 100 krad except for moths which are more resistant. In general insects become more resistant as they develop from egg to larvae, pupa, and adult, and as they become older within each stage.

Discovery of Physiological Effect of Sound on Insects. A finding of potentially great significance is that the Indian-meal moth--a major pest of foods, feed, grain, and peanuts--is adversely affected by sound waves of relatively low frequency and intensity. Only one-fourth as many moths developed from eggs laid by females exposed to these sound waves, compared with eggs laid by unexposed females. The developmental period was also longer for those that did mature. Further research may lead to the development of nonchemical control or preventive measures that will eliminate some of the pesticide residues currently causing concern.

These examples of research accomplishments illustrate the variety of work engaged in and its potential value in prevention of damage to the commodity and loss of quality. The savings made by this kind of research, benefiting both the consumer and the producer, amounts to many millions of dollars each year. The year-round supply of a great variety of wholesome, nutritious food, some of it extremely perishable, is tangible evidence of the progress in the handling, transportation and storage of food. The research of the U. S. Department of Agriculture in this field over the past 50 years has made a major contribution to the practices now in use in the marketing of agricultural commodities.

AREA 1

CITRUS AND SUBTROPICAL FRUIT - MARKET QUALITY

Problem. Research is needed to develop better objective indices for measurement of quality of citrus and other subtropical fruits. This would result in more meaningful grades and standards which could be better enforced. Instrumentation and automatic devices for quality sorting on a commercial basis might be possible. Decays and fruit soilage present serious problems in both domestic and export markets. Much research is needed to relate handling practices, packaging, precooling and transit refrigeration to wastage, and to develop effective treatments for decay reduction. There is a vast field for research on controlled atmosphere storage for oranges, grapefruit, and lemons. Problems which are sometimes distinct and sometimes interrelated exist in each of the geographical areas but which require biological research in the separate production areas for solution. Several species of common stored-product insects attack dried citrus pulp animal feed and may build up tremendous populations. In some cases wholesalers and retailers have refused to handle the product because the excessive insect infestation creates a hazard to other commodities in stock. There is an urgent need for effective preventive measures to be used in warehouses that will not leave hazardous residues in the feed, and for the development of packaging that will resist insect infestation of the product in marketing channels.

USDA PROGRAM

The Department has a continuing program involving largely applied research performed by horticulturists, plant physiologists, plant pathologists, and food technologists. The work is conducted in the producing areas of California, Florida and Texas. Market studies are made in Belle Mead, New Jersey and Chicago. P.L. 480 grants are operative for research in Colombia on avocado and papaya fruits; for studies in India on identification and mode of infection of fungi causing postharvest rots of tropical fruits; a project in Italy on X-ray detection and identification of incipient decays in citrus fruits; and in Spain on detection of additives in citrus juices. A contract study on citrus fruit quality as related to mechanical harvesting is just getting under way at the Citrus Experiment Station, Lake Alfred, Florida. Irradiation research was done in part with funds provided by the Atomic Energy Commission. Basic studies on objective measurement of maturity are being completed under contract by the California Agricultural Experiment Station at Riverside.

Total federal professional man-years devoted to this area is 10.6. Of this 2.4 is devoted to objective measurement of quality; 1.0 to quality maintenance in storage; 2.0 to quality maintenance during transportation; 1.0 to

postharvest physiology; 3.7 to postharvest disease control; and 0.5 to program leadership. P.L. 480 projects in this area involve \$64,145 equivalent over a 3-year period in Colombia; \$45,200 equivalent over a 5-year period in Italy; \$29,732 equivalent over a 5-year period in India; \$56,163 equivalent over a 4-year period in Spain; \$77,138 equivalent over a 5-year period in West Germany and a recently negotiated 5-year \$83,620 equivalent project in Israel.

Work terminated during this period included factors influencing the storage and shelf life of Florida Persian limes (MQ 2-40); ripening and storage of Florida mangos and avocados (MQ 2-46); controlled atmosphere storage of citrus fruit (MQ 2-48--replaced by related new project MQ 2-98); and control of anthracnose on avocados and mangos (MQ 2-68).

CURRENT PROGRAM OF STATE EXPERIMENT STATIONS

Research concerning market quality of citrus and sub-tropical fruit involves 22 projects in 4 States including California, Florida, Hawaii, and Texas. Research in California is designed to obtain basic information regarding the physical, chemical, and physiological characteristics of citrus fruits as influenced by storage temperature and length of storage. Other California research is involved in determining fundamental information on the physical, biochemical, and physiological changes in citrus fruit which affect quality during harvesting, processing in the packinghouse, shipment, and marketing.

Researchers in Florida are trying to develop methods for separating citrus fruits of higher internal quality which could be used by packinghouses to improve the quality of the fresh fruit pack. They are also interested in the decay and physiological breakdown of citrus fruit when subjected to various conditions of temperature, humidity, and air flow during forced air precooling.

Research in Hawaii is aimed at determining the factors that contribute to the keeping quality of fruits and vegetables in relation to shipment and marketability following quarantine sterilization, and at developing the best methods of maintaining or improving the keeping quality or marketability of these commodities under the treatments found necessary to destroy insect larvae and eggs. Texas researchers are studying methods of maintaining quality of Texas grown avocados through the marketing channel.

Disease investigations include studies to reduce fruit and vegetable decays during storage, transit, and marketing by post-harvest applications of fungicides. Some of the diseases receiving attention in these investigations are melanose, scab, and brown rot of citrus; cachexia, erocortis, stubborn disease, vein enation, wood pocket, xyloporosis, and other virus or virus-like diseases of citrus; banana diseases in Hawaii; root rot and sun-blotch of avocados, and brown spot of passion fruit.

Total market quality research effort on citrus and sub-tropical fruit at the State stations is approximately 3.3 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Relation of Physical Properties, Chemical Composition and Metabolic Activity to Market Quality. Losses in weight, volume and length during storage were observed on Florida-grown Hamlin and Valencia oranges and Marsh grapefruit. Losses were greater at 60° than 32° F., and were increased by degreening. Changes in chlorophyll content with treatment and maturity were satisfactorily followed with the light transmittance instrument.

Experiments conducted at Riverside under contract with specifically labeled sugars suggest that oxidative paths in juice vesicles may be decreasing with the progress of maturation. Alcoholic fermentation is a major metabolic path in all orange tissue and it becomes more important in the maturing vesicle. Decreases in sucrose synthesis, sucrose inversion and general sugar catabolism in various orange tissues occur during maturation of oranges. Metabolism of exogenous sugars occurs in very small pools, or reserves, during transport into the cells of orange tissues. The major changes in metabolism, so far noted, occur before the normal harvest period and so appear to have no practical application as maturity indices. The experimental work under contract has been completed and a report is being prepared. (MQ 3-20)

2. Aromatic Polynuclear Hydrocarbons in Horticultural Crops. A compound that may be anthracene has been found on 13 of 16 samples at about 0.1 to 1.0 parts per billion. Commercial sprays and waxes applied were not related to the amount of anthracene found. No carcinogenic or other 4- or more nucleated hydrocarbon has been detected by thin layer or gas chromatography techniques. (MQ 3-46)

3. The Detection of Additives in Citrus Juices. A study has been initiated in Spain under this P.L. 480 project on means of detecting adulterated citrus juice. As a first step, a very comprehensive study is being made on the kinds and amounts of natural constituents in orange juice. These include the various kinds of acids, sugars, ash constituents, and carotenoids. The relation of maturity to some of the constituents is also being made. (E25-AMS-6k)

B. Quality maintenance in storage

1. Ripening and Storage of Florida Mangos and Avocados. Optimum storage for most cold-tolerant varieties of avocados was 1 month at 40° F. The Lula variety frequently stored successfully for 2 months at this temperature.

Avocados of the West Indian strain and some varieties of other strains were cold intolerant with an optimum storage period of 2 weeks at 55°. Longer storage at 55° usually resulted in chilling injury and softening. The optimum ripening temperature for avocados was 60° to 75°, with 60° being best for eating quality.

Optimum storage for most mangos was 2 to 3 weeks at 55° F. Chilling injury was not evident at 55° and some varieties stored successfully at 50°. All mangos were affected by chilling injury when stored below 50°. The optimum ripening temperature for mangos was 70° to 75°. This work has been completed. (MQ 2-46)

2. Controlled Atmosphere Storage of Texas Grapefruit. Studies were resumed on storage of Texas red grapefruit in controlled atmospheres and air at 45° F. The best atmosphere for control of rind pitting, maintenance of good internal and external color, and retention of fresh flavor was 0.5 to 1% oxygen and 5% carbon dioxide. Decay was negligible at the end of 17 weeks' storage but severe in all lots after 7 additional days at 70°. (MQ 2-48 and MQ 2-98)

3. Postharvest Changes in Papayas. This P.L. 480 project in Colombia has confirmed recent results by the Hawaiian Experiment Station that papayas should be stored at 55° F. Lower temperatures previously recommended cause chilling injury. (S5-AMS-3)

C. Quality maintenance during transportation

1. Export Shipment of Florida Grapefruit. Simulated and accompanied export tests with Florida grapefruit resulted in recommendation of a 60° F. transit temperature during the period September to January, and 50° for the remainder of the season. Early and midseason ventilated shipment of waxed fruit proved satisfactory. The best pre- and post-transit storage temperatures were identical to the recommended transit temperatures. A sodium ortho phenylphenate (SOPP)-hexamine dip, followed by a wax treatment and the inclusion of two diphenyl pads in the container reduced decay, rind breakdown and shrivel during transit and market holding. Rough handling during loading and unloading contributed to losses during export. This work will be terminated when the report is completed. (MQ 2-74)

2. Thermal Conductivity in Florida Citrus Fruit. The thermal conductivity values for the juice vesicles of oranges and grapefruit are 3.0539 to 3.3720, whereas the thermal conductivity for the rind range from 1.3992 to 1.6416 BTU/hr/ft²/F°/in. The mean diffusivity value for whole oranges is 0.0051 sq. ft./hr. There is some indication that both moisture content and density have a slight influence in the thermal conductivity and diffusivity values. (MQ 2-53)

D. Postharvest disease control

1. Control of Decay of California Citrus Fruits. 2,6-dichloro-4-nitroaniline (DCNA) at pH 11.5 or higher and 110°-115° F. gave as good or slightly better control of Penicillium digitatum (green mold) infections in lemons than the standard sodium ortho phenylphenate (SOPP) treatment but was slightly less effective than the standard soda ash treatment.

Immersion in 130° F. water for 5 minutes or 125° water for 10 minutes gave satisfactory control of decay caused by P. digitatum on inland-grown summer lemons. Heat tolerance varied with season, geographic area, climatic conditions prior to harvest, length of time between picking and treating the fruit, and holding temperature before treatment. Hot water was not as effective as DCNA, SOPP, or soda ash at the same temperatures. (MQ 2-24)

2. Control of Postharvest Diseases of Florida Citrus Fruit. 2-aminobutane acetate effectively controlled decay on several varieties of oranges. Hot water treatment was less effective than a dip in 2-aminobutane solution but was equal or better for oranges than the standard SOPP-hexamine treatment. Hot water treatments were less effective with grapefruit and tangerines than with oranges. Increased decay of Valencia oranges following simulated mechanical harvesting was largely eliminated by prompt treatment with SOPP-hexamine. The date of artificial inoculation of oranges in the grove or the time of harvest had very little relation to development of stem-end rot after harvest. (MQ 2-65)

3. Irradiation for Control of Postharvest Diseases. Irradiation with gamma rays increased rind pitting of oranges without reducing decay during semi-commercial tests. Avocados and olives were severely discolored both internally and externally by radiation. This work will be terminated upon completion of the report. (MQ 2-82)

4. Control of Anthracnose on Mangos. As a result of previous research, equipment for hot-water treatment of mangos was installed in a commercial packing plant. Experience with fruit treated in this unit showed that a treatment for 5 minutes at 130° to 131° F. was effective for the retardation of anthracnose infections. Slight heat damage occasionally occurred on some varieties but was not of commercial importance. This work has been completed. (MQ 2-68)

5. Stylar-end Breakdown of Limes. Stylar-end breakdown, a physiological disorder of limes, was increased by dry-air heat treatments. The breakdown developed on all large mature limes exposed to temperatures of 110° to 115°F. for 24 hours; to a lesser extent on limes exposed to 70° or 105° to 110°; and not at all on comparable limes held at 50°. During the season when limes were not mature or stylar-end breakdown was not prevalent, heat treatments had little or no effect on the incidence of breakdown. (MQ 2-40)

6. Postharvest Diseases of Tropical Fruits. This P.L. 480 project in India showed good progress on isolation and identification of the pathogens involved in the diseases affecting mangos, guavas, bananas, litchis, papayas, and pomegranates during the marketing period. Progress was also made on sources of infection, particularly as related to diseases of field origin which carry over into the marketing period. (A7-AMS-6(k))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

Harding, P. L. and Sunday, M. B. 1964. Forecasting Quality and Pounds-Solids in Florida Oranges. USDA, AMS 533. (MQ 3-20)

Hatton, T. T., Harding, P. L., Reeder, W. F., Yeatman, J. N. and Krome, W.H. 1963. Fruit Weights and Corresponding Diameters for Florida Avocados. USDA, AMS 515. (BS 3-44)

Hatton, T. T., Harding, P. L., and Reeder, W. F. 1964. Seasonal Changes in Florida Avocados. USDA, Tech. Bul. 1310. (BS 3-44)

Quality Maintenance During Storage

Rygg, G. L. 1963. Experimental Storage of Dates in Bulk Bins. Date Growers' Inst. Rept. 40:8-9. (BS 2-54)

Harding, P. L., MacRill, J. R., Smoot, J. J. and Chace, W. G. 1964. Citrus Fruit and Bananas. ASHRAE Applications Data Book Chapter 52, pp. 621-634. (MQ 2)

Quality Maintenance During Transportation

Bennett, A. H., Chace, W. G., Jr., and Cubbedge, R. H. 1964. Thermal Conductivity of Valencia Orange and Marsh Grapefruit Rind and Juice Vesicles. Jour. Amer. Soc. of Heating, Refrigeration and Air Conditioning Engineering, pp. 76-77. (MQ 2-53)

Postharvest Disease Control

Smoot, J. J., and Melvin, C. F. 1963. Hot Water as a Control for Decay of Oranges. Proc. Florida State Hort. Soc. 76:322-327. (MQ 2-65)

Rygg, G. L., Wells, A. W., Norman, Shirley M. and Atrops, E. P. 1964. Biphenyl Control of Citrus Spoilage. Influence of Time, Temperature, and Carton Venting. USDA, Marketing Research Report 646. (MQ 2-28)

- Smoot, John J. and Segall, R. H. 1963. Hot Water as a Postharvest Control of Mango Anthracnose. Plant Disease Reporter 47(8):739-742. (MQ 2-68)
- Hatton, T. T. and Reeder, W. F. 1963. Effects of the December 1962 Freeze on Lula and Taylor Avocado Fruits. Proc. Fla. State Hort. Soc. 76:370-374. (MQ 2-46)
- Hatton, T. T., Wolfenbarger, D. O., and Reeder, W. F. 1963. Postharvest Effects of Dipping and Fumigating Florida Avocados with Ethylene Dibromide and Ethylene Chlorobromide. Proc. Fla. State Hort. Soc. 76:355-360. (MQ 2-46)
- Ghosh, A. K., Tandon, R. M., Bilgrami and Srivastava, M. P. 1964. Studies on Fungal Diseases of some Tropical Fruits II. Post Infection Changes in the Sugar Contents of some Fruits. Phytopathologische Zeitschrift 50(3):283-288. (A7-AMS-6(k))
- Srivastava, M. P., Tandon, R. M., Bilgrami, K. S. and Ghosh, A. K. 1964. Studies on Fungal Diseases of some Tropical Fruits I. A List of the Fungi Isolated from Fruits and Fruit Trees. Phytopathologische Zeitschrift 50(3):250-261. (A7-AMS-6(k))

AREA 2

DAIRY PRODUCTS - MARKET QUALITY

Problem.

Modern marketing practices in the dairy industry have intensified the problems of detecting inferior lots of milk and of increasing the storage life of dairy products. Several kinds of insects and mites contaminate or damage dairy products during processing, storage, and distribution. To maintain quality of these products in marketing channels, research is needed on the factors influencing keeping quality; on developing new and improved objective quality tests for bulk milk and other products; on developing safe and effective procedures for preventing or controlling insect and mite infestations; and to find improved and simplified detection methods for antibiotic and pesticide residues in dairy products.

USDA PROGRAM

There is a continuing program of basic and applied research aimed at developing new and improved methods for assessing the important quality factors in a variety of dairy products. Work on simplified methods for detecting chlorinated pesticide residues in dairy products and on the shelf-life of canned butteroil is being carried out at Beltsville, Maryland. The final write-up of results from a two-year contract with the University of California at Davis on the estimation of protein content of milk by dye-binding is nearing completion. A three-year contract with the University of Minnesota to study the quality of milk used for manufacturing purposes is nearing completion, ahead of schedule. The Federal scientific effort devoted to research in this area totals approximately 2.0 professional man-years, all in objective measurement and evaluation of quality.

There is a continuing program involving entomologists and chemists engaged in basic and applied research on the prevention of insect infestation and contamination of dairy products in the marketing channels, headquartered at Fresno, California.

The Federal effort of about one professional man-year was temporarily diverted during this reporting period to emergency research on the effects of gamma irradiation on stored-product insects, which is also pertinent to the problems of controlling insects and mites in dairy products. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dairy products.

Line Project MQ 1-13, dealing with developing improved insect-resistant packages for nonfat dry milk, was terminated with completion of the major objectives of the project, and the incorporation of upgraded packaging requirements in the ASCS purchase specifications.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research concerning market quality of dairy products is conducted under 24 projects in progress at 17 state stations. The work is part of a continuing program of research on dairy products.

Study of the factors influencing the accuracy of sampling milk is in progress. The objective of developing rapid, precise, and accurate tests for estimating the freshness of milk and for determining its butterfat or protein content and microbiological quality provides the impetus for several studies. Comparison of several rapid methods for protein determination in milk and milk products is under study with dye binding methods receiving special emphasis. One project's goal is development of a technique for rapidly determining the bacterial population of, or the extent of bacterial activity that has occurred in, raw milk and making this technique applicable for use by unskilled operators under field conditions. Another project emphasizes establishment of quality control procedures for raw milk supplies. Other related work seeks to ascertain the average value and normal range of freezing points of milk and determine the effects on freezing point of various production, environmental and processing factors.

Study of the changes in milk quality resulting from conditions associated with movements of milk to processing plants is underway. Experiments are also in progress to determine the effects of sanitation procedures on milk quality and flavor.

Insight into the causes of quality deterioration of certain dairy products such as cottage cheese, butter, ice cream and cheese is also sought. Methods of improving quality include study of controlling length of shipping time, temperature changes during storage and shipping, and general retail practice.

Other research involves improvement of the keeping quality of butter and butteroil through study of trace hydrogenation techniques and use of various antioxidants in butteroil. Factors influencing the market quality of cottage cheese are investigated. The objectives of another study include observation of the effects of composition and processing techniques on the

physical and chemical properties of ice cream and the various quality indicators of the finished product. Evaluation of the quality of and consumer reaction to milk, dry milk products, ice cream and cheeses is made to facilitate quality preservation and quality improvement in dairy products.

A total of 6.9 professional man-years is devoted to market quality research on dairy products.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Pesticide Residues. Studies of the use of thin-layer chromatography for analysis of chlorinated pesticide residues showed that this technique is faster and more sensitive than paper chromatography while at the same time retaining the advantage of simplicity and low cost. Details of procedures were worked out using thin-layer plates prepared from alumina or silica gel with a small amount of silver nitrate to develop a dark spot under ultraviolet light in the presence of chlorinated compounds. Florisil and carbon-celite chromatographic cleanup techniques were found satisfactory for sample preparation. Some lots of florisil purchased recently contain excessive amounts of interfering materials and it will be necessary to develop a procedure for removing these before the florisil can be used for cleanup of samples.

(MQ 3-11)

2. Protein Content. The study on the estimation of protein content of milk by dye-binding is being carried out at the University of California. During the past year, statistical analysis of the data was completed and preparation of the material for publication is nearing completion. Statistical analyses showed that a better relation between dye-bound and protein can be obtained if a correction for fat content is included in the regression equation. No explanation can be made for this effect.

(MQ 3-14(c))

3. Manufacturing Milk. A survey of the quality of milk for manufacturing was carried out under contract with the University of Minnesota. (Collection and analysis of samples were completed well ahead of schedule. The data have all been transferred to punched cards for statistical analysis.) Preliminary examination of the data indicate that even with refrigerated bulk tanks, some producers are selling milk of rather poor quality, indicating lack of attention to sanitary practices. Reduction methods and direct microscopic counts tend to grade milk somewhat more leniently than the standard plate count when the proposed U.S.D.A. standards for each method are used.

(MQ 3-44)

4. Stability of Anhydrous Butterfat. Samples were put in storage in sealed cans at 32°^o, 70°^o and 100°^o F. Sampling after six months-storage showed little change at 32°^o F, some at 70°^o F, and more at 100°^o F. Chemical tests run were the peroxide value and the thiobarbituric acid test and the samples were also evaluated organoleptically. The slight deterioration observed was not sufficient even at the 100°^o F storage for six months to cause the samples to be unacceptable for use.

(MQ 3-49)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Moats, W. A. 1964. One-step cleanup of chlorinated insecticide residues by chromatography on carbon-celite mixtures. J. Assoc. Off. Agr. Chem. 47:587.

(MQ 3-11)

AREA 3

DECIDUOUS FRUIT AND TREE NUTS - MARKET QUALITY

Problem. Deciduous fruits and tree nuts are subject to deterioration after harvest through normal metabolic processes and from decay organisms. In addition these products vary widely at harvest in the characters that determine market acceptance. Practical objective measurements of quality would greatly assist in standardization and grading procedures, and the development of instrumentation for this purpose increases the chance for automatic quality sorting on a commercial basis. Additional information is needed on physical and chemical methods for decay reduction and on product quality as related to mechanical harvesting. Research is needed on storage environment as related to temperature, air movement, humidity, atmosphere modifications and fumigants. Continued research is needed with transportation equipment and services as affecting ultimate quality of the product in the market.

Dried fruits and tree nuts are subject to insect infestation while drying in the field, during storage while they await processing, in the processing plant, and in marketing channels until they reach the final consumer. Research is needed to develop more effective measures for preventing insect infestation all along this line. Emphasis must be given to finding methods that will keep both insect contamination and pesticide residues at minimum levels.

USDA AND COOPERATIVE PROGRAM

The Department has a long-term program of basic and applied research involving horticulturists, plant physiologists, plant pathologists, and food technologists. The research includes both measurement of quality and maintenance of quality during the period between harvest and consumption. Locations include laboratories at Beltsville, Maryland; Wenatchee, Washington; Fresno, California; Raleigh, North Carolina; Chicago, Illinois; and Belle Mead, New Jersey; and contract work at Corvallis, Oregon with the Oregon State Experiment Station. Research on gamma irradiation of fruits and vegetables has been under way at the Fresno laboratory with some financial help from the Atomic Energy Commission. Cooperative agreements and limited contributed funds were in effect with the California Strawberry Advisory Board. P.L. 480 supported research is under way in England on the effects of modified atmospheres on the physiological processes of apples; in Finland on fungicide residues and postharvest effects on fruits as related to time and rate of spray application; and in Italy on the principal rots of apples and pears.

There is a continuing program at Fresno, California, involving entomologists in applied research on the prevention of insect infestation and pesticide residues in dried fruits and tree nuts. The work is conducted in cooperation with California State and County agencies and with several industry groups. In addition to the direct work at Fresno, much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in dried fruits and tree nuts.

Federal effort in this program totals 19.0 man-years divided as follows: objective measurement of quality 2.9; quality maintenance in handling and packaging 1.3; quality maintenance in storage 3.7; quality maintenance during transportation 1.5; postharvest physiology 1.8; postharvest disease control 4.0; prevention of insect infestation 3.0 and program leadership 0.8. Research under P.L. 480 includes a 4-year project in Finland on chemical residues for a total of \$56,637 equivalent; a 5-year project in England on the biological effects of modified atmospheres for apples at \$67,031 equivalent; and a 3-year project in Italy on apple and pear rots for \$18,357 equivalent.

Work terminated during the period included: softening of brined cherries (MQ 2-16); temperature and fungicides on peaches (MQ 2-22); and sulfur dioxide treatment of grapes. (MQ 2-49) Line Project MQ 1-10, dealing with the fumigation of tree nuts, was discontinued because of the unavailability of sufficient personnel to conduct the work.

PROGRAM OF STATE EXPERIMENT STATIONS

Eighty-seven projects in twenty-eight States are devoted to market quality research for deciduous fruit and tree nuts. These studies include research on sizing, packaging, cooling, storage, and handling as well as the determination of the effect of chemicals and packaging films on storage life, chemical changes, and quality of refrigerated fruits and vegetables.

There are two regional projects in this area of research. NEM-27 is entitled Post Harvest Physiology of Pomological Fruits and is concerned with the development of objective methods of measuring maturity, ripeness, and condition of fruits for fresh market and processing; with the establishment of principles most conducive to maintenance of high quality fruits during the post-harvest period; and with the investigation of physiological and biochemical processes occurring in harvested fruit. WM-26, entitled Consumer Purchase and Utilization of Selected Fruits and Vegetables in the Western Region, is designed to determine the factors affecting consumer preference, purchase and utilization of fruits and vegetables in fresh and processed forms; and to determine the quality and cost of selected fruits and vegetables available to the consumer in fresh and processed forms in retail stores.

Disease research includes numerous projects which indirectly bear a relationship to improvement of market quality. Examples of pathological research contributing directly to improved market quality of fruits and nuts in the marketing channel are California projects on post-harvest diseases of fruits and vegetables, products formed by fungi in rot of fruit, chemical control of post-harvest fruit and vegetable decays occurring in packinghouses, and post-harvest rots of peaches and other stone fruits in transit and storage; and New Jersey research on preservation of the quality of freshly harvested produce through the control of decay-producing organisms.

Total market quality research on deciduous fruit and tree nuts at the State stations is approximately 34.7 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Eastern Apples. A correlation of $r = .784$ was found between the readings with the light transmittance difference meter and the Magness-Taylor fruit pressure tester. Data used were mean values of 4 sample lots for each of 5 weekly harvests. The Automatic Fruit Internal Quality (IQ) Sorter was tested extensively with Golden Delicious, Stayman, Red Rome and Winesap apples. Low chlorophyll content was highly correlated with eating quality, as determined by a taste panel. Low chlorophyll fruits were slightly firmer than high chlorophyll fruits throughout the test. Comparisons of the Magness-Taylor pressure tester with the mechanical thumb on 5 varieties of apples showed significant differences between readings, largely as related to variety. Ripeness of the fruit, as related to instrument reading, is being determined by panel evaluation. (MQ 3-28)

2. Western Apples. The chlorophyll content in individual apples from a single Starking Delicious tree widens as the number of days from bloom increases. Considerable variation in the chlorophyll content of fruit from different trees was evident. There was less tree to tree variation in soluble solids and acidity; these being more closely associated with number of days from bloom. Chlorophyll content and flesh firmness were inversely related in fruit of early harvests. Separation of water-cored Delicious by light transmittance proved effective again this season and appears to be ready for commercial application. Water core disappeared from Starking Delicious apples more rapidly at 65° than at 31°F. but loss in quality was rapid at the higher temperature. (MQ 3-28)

3. Red Tart Cherries. Cherries sorted with the light transmittance difference meter showed sound, normal cherries within the 0-30 range. Three percent scalded fruits or 20% with other defects did not downgrade the frozen product. Scald results from bruising followed by an oxygen deficiency. Under these conditions the anthocyanin pigments migrate from the skin into the flesh resulting in the scalded appearance although the total anthocyanin remains constant. Bruised cherries held in air did not scald. Scald occurred

in bruised cherries in the commercial soak tanks with low oxygen concentrations. Limited tests indicate that pumping air through the soak tank may prevent scald. (MQ 3-27)

B. Quality maintenance in handling and packaging

1. Film Liners for Apples. Equipment and basic techniques were developed and numerous permeability tests made at 32° to 68°F. at Beltsville. Logs of gas transmissions rates were approximately linear to reciprocals of Kelvin degrees. The variation coefficient was 8.7 percent for film types. Identical samples varied 2.5 percent. Variations were greatest in plasticized films. Film diffusion temperatures averaged higher than ambient temperatures. Diurnal pressure effects were less than seasonal effects. Of 1900 film samples examined, 75 percent exceeded the stated gage, but 4 of 5 types averaged less than 2 percent variation. Physical changes, detectable by light frequencies of 1.8 to 12.5 microns, were serious in one film type. Some film liners deteriorated during prolonged apple storage. Film deterioration was most severe when the liner contained Delicious or Stayman Winesap apples indicating that apple volatiles may have been involved. The scald inhibitor, santoquin, used on some test fruit may also be responsible for film deterioration. Stress cracking of films occurred in 28 tests at 32°F. A light refraction test helped detect film flaws.

Pads containing 1 pound of hydrated lime within sealed polyethylene-lined boxes of apples held carbon dioxide within the container below 1% during 5-7 months storage at 32°F., compared with 4-7% CO₂ without lime. The oxygen content was also slightly less and the ethylene content higher, 4500 ppm vs 900 ppm without lime. The post-storage respiration rate of fruit was reduced 18% by previous storage in sealed liners without lime but only 10% with lime pads. Use of lime pads eliminated CO₂ injury (core flush) on Rome Beauty and Stayman apples packed in sealed polyethylene. (MQ 2-63)

2. Blueberries. Paper chromatography analysis of North Carolina-grown Wolcott blueberry fruits showed 14 amino acids; citric, malic, succinic, and quinic acids; and fructose and glucose. During ripening malic acid increased slightly while citric, succinic and quinic acids decreased. Amino acids did not change significantly. Fructose and glucose were present in nearly equal quantities at all stages of ripeness; both increased during ripening.

Decay in mechanically injured fruits increased as harvest maturity advanced, from about 17 percent of the green fruits to nearly 100 percent of the over-ripe fruits. Botrytis cinerea was the predominant cause of decay at 35°F. while Alternaria species predominated at 75°F. (MQ 2-94)

C. Quality maintenance in storage

1. Eastern Apples. Using 16 different controlled atmospheres for Red Delicious apples, the best overall results were obtained with 1 to 3% oxygen with or without CO₂. Below 1% oxygen (near zero) both injury and off-

flavors were evident. No typical scald symptoms occurred in any of the atmospheres with 1% or less oxygen. The firmest fruit after storage was from the near zero O₂ atmospheres; next from the 1% O₂ atmospheres and the softest fruit from the 3 or 21% O₂ atmospheres. Neither DPA nor hot water reduced scald appreciably in fruit stored at 5% CO₂ and 21% O₂. (MQ 2-63)

2. Plums. Laroda, Santa Rosa, and Nubiana plums were separated into groups differing in soluble solids, by flotation in a series of sodium chloride solutions. Wickson plums could not be sorted in this way because cavities of various sizes occur in the fruit. Since plums of less than 12% soluble solids do not ripen with good quality, this technique could be used to eliminate low quality fruit in some varieties.

Nubiana plums in sealed polyethylene lug liners, remained in better condition after 9 weeks' refrigerated storage than comparable fruit in vented liners. The fruit in sealed liners was firmer and had less decay than the fruit in vented liners. (MQ 2-12)

3. Sweet Cherries. Lambert cherries held for 25 days at 31°F. in atmospheres containing 10 percent carbon dioxide with 3 percent or higher oxygen, had fair quality after an additional 2 days at 70°F. The carbon dioxide retarded decay and acid loss in the cherries and preserved their fresh appearance. Results were comparable to those obtained with the use of sealed polyethylene liners. (MQ 2-99)

4. Grapes. After 3 months' storage, Emperor grapes that were hydrocooled had fresher stems, brighter red berries, and less weight loss than fruit cooled in air. Hydrocooled fruit was either fumigated in the conventional manner immediately after cooling or the SO₂ was applied in the hydrocooling water. Either method controlled decay as well as conventional fumigation in non-hydrocooled lots. No significant berry splitting occurred in hydrocooled Emperors, but up to 30% occurred in Thompson Seedless. The half-cooling time for packed grapes in a pilot-size hydrocooler was about 1 minute, varying slightly with flow rates of 10 to 40 g.p.m./ft.² of cooler area. (MQ 2-49)

D. Quality maintenance during transportation

1. California Strawberries. When a mixture of 1,1,1-trichloroethane and dichloromethane (SDV) was used alone at simulated transit temperatures it was as effective as carbon dioxide (CO₂) in reducing Botrytis decay of strawberries. In combination with CO₂, it was no more effective than the CO₂ alone, and in some experiments internal breakdown occurred in the SDV-treated berries. (MQ 2-83)

An air shipment of strawberries from California to New York with dry ice included, provided relatively high levels of CO₂ in the insulated container (17-37%) and the oxygen level did not fall below 7%. With the berries pre-cooled to only 49°F. before loading, transit temperatures were in the 50-55°

range. Berry condition was rated excellent on arrival and during 2 subsequent days at 60°. (MQ 2-83)

2. Simulated Transit in Nitrogen Atmosphere. Decay of red raspberries, held an average of 5-1/2 days at 50°F. was significantly less in an atmosphere of total nitrogen than in air. Atmospheres containing 0.25% or 1% oxygen with 99.75% and 99% nitrogen, respectively, were also beneficial in reducing decay. (MQ 2-71)

E. Postharvest physiology

1. Apple and Pear Scald. A 10-second dip in 2000 ppm diphenylamine (DPA) at 70°F. markedly reduced apple scald in tests at Beltsville with 4 varieties of apples. In two tests, heating the DPA suspension to 120° improved scald control as compared with the 70° dip but increased chemical injury. A 10-second dip in 500 ppm at 70° gave poor scald control on Delicious and Rome varieties but good control on Stayman apples. A 10-second dip in 500 ppm DPA heated to 120°F. was comparable to 2000 ppm DPA at 70° for all varieties. A 30- or 60-second dip in water at 130°F. provided scald control comparable to that obtained with DPA on Delicious and Stayman apples, but did not control scald on early picked Rome Beauty apples, and injured York Imperial apples.

Delicious and Winesap apples and Anjou pears were treated at Wenatchee with scald inhibitors in dips, waxes, and impregnated wraps and combinations of dips or waxes and wraps. Ethoxyquin applied in a wax, water suspension, or an impregnated wrap reduced the incidence of Anjou scald after 210 days storage at 31°F. Plain wax increased the amount and intensity of Anjou scald. Diphenylamine did not control scald on Delicious apples when applied in a wax, water suspension, impregnated wrap or combinations of the treatments but the same treatments produced excellent control of storage scald on Winesaps.

DPA residues were highest immediately after treatment in dip and wax treatments and decreased with storage time. The residues on fruits dipped in DPA and wrapped in DPA impregnated wrappers never exceeded 4.4 ppm. Residues on Delicious were generally lower than those on Winesap. (MQ 2-91)

Ethylene oxide at concentrations of 1.0 to 2.5% applied by gassing and by dipping soon after harvest caused severe injury to the 4 varieties of apples treated. The treated fruit was no firmer after 3 months storage at 32°F. than the controls. However, following storage, ethylene production was markedly inhibited in the treated fruit. (Exploratory Research)

2. Apple Respiration at Modified Atmospheres. These studies, undertaken at the Ditton Laboratory in England have shown that the respiratory quotient (CO_2 produced/ O_2 consumed) was much higher than would be expected from widely accepted concepts of substrates used in respiration, i.e. malic acid and sugars.

The extension of storage life conferred by controlled atmosphere storage was more closely approximated by oxygen uptake than by CO₂ production. As would be expected, respiration was reduced with lowering of temperatures, increasing CO₂ or lowering of O₂ levels, through the range of 54 to 32°F. When low temperature injury occurred, respiration rose to that equivalent of much higher temperatures. For reasons as yet unexplained, the respiration quotient rose as temperatures were reduced, and fell as its concentration of CO₂ in the atmosphere was increased. (E29-AMS-1(a))

3. Anjou Pear Scald. Anjou pears exposed on the tree to almost 300 hours below 50°F. in the 2 weeks just before harvest developed as much scald during storage as fruit exposed to temperatures continuously above 50°. These results did not confirm the hypothesis proposed by other work that high temperatures prior to harvest predispose fruit (apples) to scald. Santoquin (ethoxyquin) as a dip or in wraps gave excellent control of Anjou scald during each of two storage seasons; diphenylamine dips or wraps did not. Treatment with Santoquin after several months of storage did not provide scald control. Gas chromatographic analyses show volatiles to be similar in quantity and quality in scalded and non-scalded pears. Chlorogenic acid and catechin in the skin of Anjou pears decreases more in those treated with Santoquin than in non-treated. (MQ 2-66)

4. Lenticel Spotting of Golden Delicious Apples. A severe type of injury, characterized by a halo of discolored tissue around the lenticel, was found in Golden Delicious apples which had been packed and stored with urea-formaldehyde resin impregnated in paper. Similar injury had been found last year in pulp trays containing the same resin. Pulp or plastic trays without the urea-formaldehyde resin caused no significant injury. (MQ 2-72)

F. Postharvest disease control

1. Forecasting Storage Diseases of Apples. Ten grower lots each of Delicious and Winesap apples were washed in a fungicide (sodium-o-phenylphenate) and held at 70°F. in polyethylene bags at Wenatchee. After 21, 28 and 35 days decay, mostly blue mold, ranged from 1 to 3 percent. One lot of Winesaps developed 52% storage scab after 35 days. In samples of comparable commercial lots of fruit examined after 210 days in cold storage, blue mold decay ranged from 0 to 3%, while storage scab in the single lot of Winesaps was 46%. (MQ 2-67)

2. Grapes. Continuous exposure to ozone (1 ppm) in a commercial grape storage was not effective in controlling Botrytis rot in Emperor grapes during 2 months' storage at 32°F. Grapes initially fumigated with 1 percent SO₂ and then held in an ozone-treated room had approximately 2/3 as many decayed berries as those without the initial SO₂ treatment. Grapes fumigated in the conventional manner with SO₂ (initial plus weekly fumigations) had only 1/6 as much decay as those treated only with ozone. (MQ 2-102)

3. Blueberries. Dips in sodium salt of dehydroacetic acid solutions at 0.1 to 1.0% or in 2-aminobutane at 1.0% concentration were ineffective for reducing postharvest spoilage of blueberries. Hot-water treatments (5 minutes at 120°F., 2 minutes at 125°, or 1 minute at 130°) reduced decay over non-treated lots but caused some heat injury particularly in late-picked fruit. Hot-air treatments at high relative humidity also reduced decay and caused less injury than hot water. (MQ 2-45)

4. Strawberries and Raspberries. At Beltsville, heated air at high relative humidity or a 0.4 percent solution of dehydroacetic acid reduced postharvest decay of raspberries and strawberries as compared with wet and dry checks during 4 days holding at 60°F. Heated air at relative humidities below 70 percent did not reduce decay. Hot water (110°) dips injured strawberries, but 125° dips for 1 to 2 minutes effectively reduced raspberry decay. (MQ 2-104)

Strawberries were treated at Fresno, California with heated air at 100 percent relative humidity for periods up to an hour. In two experiments decay was reduced from about 25% to about 4% by exposure to 111°F. for 1 hour, but slight injury to the berries was also observed. (MQ 2-83)

5. Cranberries. Cranberries from one location in Massachusetts, which were dipped in hot water developed significantly less spoilage after 4 months' storage at 38°F. plus 7 days at 70° than did non-treated berries. Spoilage was not reduced in berries obtained from 2 other locations. (MQ 2-45)

6. Gamma Radiation Treatments. Pasteurizing doses of gamma irradiation extended the market life of strawberries and two varieties of figs by several days through reduction of decay, without apparent impairment of fruit quality. Brown rot, but not Rhizopus rot, of peaches and nectarines was controlled; the peaches softened during irradiation and subsequently developed more red color, but less flavor than the controls. Radiation inhibited blue coloring of plums and increased softening of the fruits. Low doses inhibited ripening of pears by several days, but ripening was abnormal. Irradiated apples were softer, more shriveled, and had less flavor than the controls following storage for 3 to 6 months. Individual varieties of peaches and figs responded quite differently to radiation. Water on the surface of peaches during irradiation caused spotting of the skin. Fruit maturity within the limits of these experiments did not affect the responses to radiation.

Decay of inoculated grapes was substantially reduced by irradiation before the infections had become established. However, the effectiveness of a given radiation dose was reduced as the concentration of spores on the grapes increased. Established fungal infections were more resistant to radiation than spores, and infections became increasingly resistant with age. Similar increases in resistance of infections as they developed were observed in oranges. In general, the effectiveness of a given radiation dose decreased as the number of cells to be inactivated increased, whether the cells were in the form of spores or mycelia. This work will be terminated upon completion of the report. (MQ 2-82)

7. Radiation on Pathogenicity of Fungi. Forty-four mutants of Penicillium expansum were tested for their virulence, using Jonathan and Red Delicious varieties of apple. Only those mutants requiring methionine were able to invade both varieties and an arginine-requiring mutant could not decay the Red Delicious variety. In vitro and in vivo supplementation studies indicated that inability to invade tissue was related to the relatively low concentration of the required amino acids at the site of inoculation. One heterocaryon (vegetative mycelium which contains a mixture of haploid nuclei other than the original type) and the corresponding diploid strain involving 2 avirulent methionine-requiring mutants, could cause decay. Mutant loci in 3 diploid strains could be assigned to 2 linkage groups by means of the parasexual cycle. In vitro tests with 7 antimetabolites and growth factor analogs for the inhibition of growth of Penicillium expansum showed none to be effective when compared with the fungicide dehydroacetic acid. (MQ 2-96)

8. Pesticide Residues. This P.L. 480 project in Finland on postharvest chemicals showed that CIPC and IPC (sprout inhibitors and fungistats) disappear rather slowly from stored fruits. The rate of disappearance increases with temperature in stored apples, plums and tomatoes. Postharvest application of CIPC, IPC, and captan (fungicide), indicate that captan improved the keeping quality of plums and ripe tomatoes but caused marked chemical injury to apples during storage. IPC and CIPC were effective for the reduction of postharvest decay in plums, ripe tomatoes, and apples but inhibited color development on plums and mature-green tomatoes during storage. Storage decay was increased in stored carrots with either CIPC or IPC applications. (E8-AMS-1(a))

9. Apple and Pear Rots. This P.L. 480 project in Italy, is concerned with the important fungi causing rots, their mode of entry, rate of development at different temperatures, and characteristic symptom. Useful information has been obtained on rots caused by spores of Botrytis, Penicillium, Gloeosporium, and Alternaria. Rate of decay as related to maturity of fruit at harvest and interval of storage before inoculation is also being obtained for several organisms. Detailed drawings and colored illustrations will be prepared as the project progresses. (E15-AMS-2)

G. Prevention of insect infestation

1. Insecticide Evaluation. Results from the first quarter of an extensive 1-year laboratory study of malathion as a protective treatment for raisins, almonds, and walnuts indicated that a dust treatment was superior to spray even though the amount of malathion applied was less. Young stages of the Indian-meal moth and merchant beetle appeared to be most susceptible, and adults of the dermestid beetle, Trogoderma inclusum, the most resistant of the insects tested. Protection of raisins against infestation seemed to be better thus far than that obtained through the use of malathion-treated drying trays. (MQ 1-15)

2. Insecticidal Control. A series of 9 dichlorvos thermal aerosol applications in 3 different wineries gave unintentional wide extremes of vapor concentrations, indicating the need for better control over rate of application and for more knowledge of factors influencing dosage-concentration ratios. All applications gave significant reductions in numbers of vinegar flies in the wineries, effective control lasting 3 to 12 days, with an average of 8. Mineral oil as the carrier gave a denser aerosol and had less objectionable odor than when diesel oil was used. (MQ 1-34)

In final observations on tests started in 1962, raisins stored for 1 year after being dried on malathion-treated trays contained fewer living insects and showed less increase of insect fragments than did those dried on untreated trays. Processing greatly reduced the amount of foreign material in the raisins and generally reduced the amount of malathion residue. There was an interesting shift in predominant insects during the last 2 or 3 months the raisins were in storage. The raisin moth was most abundant during the first 9 months but almost disappeared during the last 2 months when the Indian-meal moth, saw-toothed grain beetle, and dermestids appeared. (MQ 1-34)

In supplemental observations it was found that raisins contained significant amounts of malathion after drying 1 week on treated trays and the malathion reached the maximum amount after 2 weeks. From 60 to 90 percent of the malathion was in the outer "waxy bloom" of the raisins. Significantly fewer insects were found in raisins from carefully picked, uninjured grapes than in those from typical commercial picking. (MQ 1-34)

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AREA 4

GRAIN - MARKET QUALITY

Problem. Grain and cereal products are subject to damage or deterioration in quality while in the marketing channels through normal metabolic changes, by the action of micro-organisms, and by the attack of more than 50 species of stored-product insects. This deterioration affects the grade and price received, the end use, and the wholesomeness of the product. Its effect may be conspicuously blatant, or insidiously hidden; may result in the destruction of nutrient values, or insects may render it esthetically unacceptable. Research is needed not only to protect this multibillion dollar crop from evident deterioration but from the hidden damage as well. Surplus crops and longer storage periods make once accepted standard procedures obsolete. New methods of protection from insects and disease, of identifying and measuring quality changes, and means of maintaining quality over longer periods of time are some of the problems requiring attention.

USDA PROGRAM

The Department has a continuing program involving chemists, engineers, and plant pathologists in basic and applied research on the quality evaluation, quality maintenance and development of objective methods for quality evaluation of cereal grains. The research is conducted at Beltsville, Maryland, and Watseka, Illinois, and also by research contract with Shuman Laboratories, Battle Ground, Indiana.

The program includes the following foreign projects under PL 480: a grant to the Israel Institute of Technology, Haifa, Israel, provides for a study to develop tests for nutritive value of cereal grains and feeds. Its duration is 4 years, 1960-1964, and involves PL 480 funds with a \$103,785 equivalent in Israeli pounds.

A grant to the Agricultural Higher School, Poznan, Poland, provides for a study of the effect of microflora of wheat flour on its stability, biochemical, and technological properties. Its duration is 4 years, 1961-1965, and involves \$13,091 equivalent in Polish zlotys.

The Federal scientific effort devoted to research in this area totals 6 professionals divided as follows: quality maintenance and evaluation 5; and contract research 1.0.

There is also a continuing program involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination of grains and cereal products in the marketing channels.

The work at Manhattan, Kansas, and Tifton, Georgia, is in cooperation with the respective State Agricultural Experiment Stations. The work at Tifton, Manhattan, Savannah, Georgia, and Watseka, Illinois, is in cooperation with the Agricultural Stabilization and Conservation Service, and 1 professional man-year of effort at Manhattan, Savannah, and Watseka is supported by Commodity Credit Corporation funds. The CCC also makes available various commodities and storage facilities for experimental use. There is cooperation with engineers of the Transportation and Facilities Research Division on matters relating to storage structures and aeration; and with the Field Crops and Animal Products Branch of this Division in studies relating to quality maintenance during storage, and on quality evaluation of grains and cereal products. There is cooperation with growers' cooperatives at Manhattan and with various industry groups at all locations. There is also overall cooperation with the State Experiment Stations in Regional Project WM-16, "Maintaining Grain Marketability by Insect Control in Storage."

Contract research included work at the Auburn University Agricultural Experiment Station, Auburn, Alabama.

A grant to the Hebrew University in Rehobot, Israel, provides for extensive studies on the effect of ethylene-dibromide-fumigated feed on domestic farm animals. It became effective in 1961, expired in August 1964, but has been extended to August 1966 with PL 480 funds with a \$58,733.33 equivalent in Israeli pounds.

Another grant to the Hebrew University at Jerusalem, Israel, is for basic research on the influence of environmental conditions on the population dynamics of the khapra beetle. It became effective in 1961, continues to October 1964, and involves PL 480 funds with a \$58,240 equivalent in Israeli pounds. A 2-year extension is under negotiation.

A grant to the Administration of Agricultural Reserves and Surpluses, Montevideo, Uruguay, is for the study of underground storage of corn in air-tight silos in relation to maintaining quality and preventing insect infestation during long-term storage. It became effective in 1962, continues to May 1967, and involves PL 480 funds with a \$70,143.38 equivalent in Uruguayan pesos.

A grant to the Instituto Superiore di Sanita in Rome, Italy, is to study the fate of insecticide residues on wheat during storage, milling, and baking or processing into wheat products. It became effective in 1963, continues to March 1967, and involves PL 480 funds with a \$98,319.16 equivalent in Italian liras.

A grant to the Direzione Generale dell' Alimentazione, Ministry of Agriculture and Forests, Rome, Italy, is for the study of insect infestation in macaroni, noodles, and spaghetti, and of ways to prevent this infestation. It became effective in 1962, continues to November 1965, and involves PL 480 funds with a \$42,621.90 equivalent in Italian liras.

The Federal scientific effort devoted to research on prevention of insect infestation totals 10.7 professional man-years, which includes 1.0 man-year of contract research. In addition, much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in grain and grain products.

Line Project MQ 1-30(C), covering a study of the insect damage to corn in the Southern States at time of harvest and during storage, was discontinued with satisfactory completion of the contract research involved.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations are engaged in both basic and applied research on the market quality of grains. A discussion of the program on insect control is included under Area 13.

Considerable effort is devoted to the varietal and quality improvement of grains. For example, when barley is grown for malting purposes, the malting factors are evaluated to determine what effects various varieties, cultural practices and environments have on malting quality. Twelve States are researching the various phases of quality of cereals. The 4 Federal regional wheat laboratories are located in 4 of these States. Both State and Federal researchers cooperate closely on this program. Research on the quality of soft red winter wheat is coordinated through the NCM-28 regional project, with the Federal laboratory at Wooster, Ohio, participating in this regional project along with the Ohio, Indiana, and Missouri stations. Basic studies involve the improvement of testing methods, the chemistry of bleaching action on starch, lipid and protein interactions in cake baking tests, and the identification of proteins and amino acids associated with good baking quality. Fractionation of flour, particle size, as well as density and air classification, is being studied with wheat flour.

The quality characteristics of experimental strains of wheat are evaluated as well as changes in quality of wheat associated with time and conditions of storage. The various chemical and physical measures are applied in evaluation of quality factors.

There are about 5.7 professional man-years devoted to research on the market quality of grains.

Insect Control. A discussion of the program of the State Experiment Stations in this area is presented under Area 13, "Insect Control in Marketing Channels--Cross Commodity."

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Quality Indicators for Stored Wheat. A hard red winter wheat variety, Triumph, and a hard red spring variety, Selkirk, of the 1963 crop were stored for 32 weeks at 86° F. and 60 weeks at 50° F. Sedimentation values decreased during the storage period with the greatest decline in the spring variety. Fat acidity values generally increased faster in the spring variety. At 16, 14, and 12 percent moisture the decline in overall quality was in direct ratio to the moisture content. Also, the changes were slower at 50° than at 86° F. (MQ 3-3)

2. Effect of Excessive Heat on Corn Quality During Artificial Drying.

(a) Effects of harvesting and drying. Corn was harvested at various moisture contents from 33 to 9 percent, and dried at temperatures from 70° to 200° F. Corn dried at 200° F. and subjected to impact tests showed 11 percent by weight passing through a 12/64-inch screen vs. 3 percent when dried at 70° F., and thus is more fragile. It is also about 3 percent lighter in weight, and is more subject to molding than field-dried corn when subjected to high-humidity storage conditions. Corn harvested at 19 percent moisture and dried at 160° F. retained partial viability.

(b) Moisture distribution in corn samples as an indication of damage by heat. Instrumentation for measuring capacitance (total moisture) and resistance (surface moisture) has been improved, and tests made on a series of corn samples dried at temperature of ambient to 290° F. The higher drying temperatures resulted in lower starch yields, and this was correlated with the capacitance-resistance measurement. This measurement also gave a high correlation with the viability of the samples mentioned in (a).

(c) Glutamic acid decarboxylase activity as an indication of damage by heat in corn. This procedure has been shown to be of some value as a means of detecting damage to corn by overheating. It shows a significant correlation with the capacitance-resistance measurements. It is primarily a laboratory method and serves as a check on other methods. (MQ 3-18)

3. Moisture Measurement and Equilibria in Grain. Times and temperatures required for oven drying different species of seed to give a weight loss corresponding to the standard method were determined. Results obtained by

the oven method were then used to prepare tentative calibration charts. Charts have been prepared for the Motomco moisture meter for 4 species of grass seeds, 11 species of vegetable seeds, and 4 species of tree seeds.

(MQ 3-23)

4. Sampling Research. Commercial devices for sampling grain as it is loaded into or out of a hopper car, or while the grain is stationary in the car, were tested extensively. The results indicate that one spout type sampler was quite superior to the other samplers tested, and gave a reasonably accurate sample of the grain being tested. A pneumatic sampler for sampling grain at the ASCS binsite was developed and a prototype constructed. This sampler was widely tested and proved superior to all others. State ASCS officials have recommended that it be adapted for official use in routine sampling of binsite stored grain. The Grain Division, AMS, has purchased 50 units and will field test them for sampling grain shipped in 100-ton hopper cars.

(MQ 3-24)

5. Standardized Lighting Conditions for Grading Grain. The manuscript on the "Evaluation of Background Colors for Grain Inspection" has been completed. This project will be discontinued upon final editing of the manuscript.

(MQ 3-30)

6. Test Weight-Flour Yield. Factors such as weight, kernel size, pearling index, pentosan or bran content vary in how closely they are correlated with flour yield in different classes of wheat. Of the factors studied, only weight and bran content were significantly correlated with flour yield in all 4 classes. A manuscript has been submitted for publication.

(MQ 3-36)

B. Quality maintenance in storage

1. Wheat Storage-Quality Changes Due to Insecticides. The wheats treated with insecticide materials Cab-o-sil; Silica Aerogel 68, Perma Guard, and Kenite showed a significant decrease in test weight per bushel but not in yield of flour, as compared with the untreated wheat. There was no change in the test weight or flour yield of the malathion-treated wheat. The CR (capacitance-resistance) and GADA (glutamic acid decarboxylase activity) tests evidenced marked changes during the recent 6-month storage of the 1963 crop wheat. The recently insecticide-treated 12-year-old wheat decreased also in CR values. GADA tests were not made on this older wheat since the enzymatic activity was almost nil when tested initially. Changes between the initial and 6-month storage tests for the sedimentation values, diastatic activity, dough properties and bread-making was small and about the same for the control as the treated wheats.

(MQ 0-0-1(CCC))

2. Corn Storage Research. Preliminary evaluation of the results to date have not indicated any overall difference between several methods of aeration in the control of deterioration by fungi in quonset types or round steel bins. (MQ 0-0-2(CCC))

3. Wheat Storage-Quality Changes Due to Radiation. There was a significant initial loss in sedimentation values with increasing levels of radiation as contrasted to no change taking place in fat acidity. Germination values were unchanged from the control values for the 10 and 25 thousand rad treatments but decreased materially for higher gamma dosages. Radiation dosages of 125 and 175 thousand rads produced distinct off odors (burned or charred) in the hot breads. Bread-baking properties (loaf volume, etc.) were not influenced by the various levels of radiation treatment. However, in contrast to the initial changes, some changes are occurring in the wheats stored for 6 months. These seem to be related to both radiation treatment and storage. (MQ 1-12)

4. Microflora of Wheat. No significant correlation could be observed between the climate and soil conditions and the grade as well as character of the flour. There was no distinct difference between the samples of Polish and imported wheat as far as the exterior microflora was concerned. However, there was a difference in the interior infection: Approximately 84 percent of the Polish soft wheats showed infection while the imported samples were found to be free of internal infection. (E21-AMS-7(k))

C. Prevention of insect infestation

1. Basic Biology and Ecology. In studies on the effect of air movement on stored-grain insects, indications thus far are that if favorable environmental conditions are maintained, physical air movement ranging from 0.05 to 1.0 c.f.m./bu. has little direct effect on the survival and development of rice weevils in wheat. In an exploratory experiment, adult rice weevils were placed on the surface of wheat at 65° F. There was no significant movement of the weevils to warmer grain a few inches under the surface. This does not seem to agree with the theory that insects tend to move toward warmer areas of a grain mass, but raises a question as to whether the rice weevil might follow a preferred temperature zone as it moved slowly through a mass of grain. The behavior of other species also remains to be investigated. (MQ 1-18)

Confused flour beetles were preconditioned to a high respiration rate in carbon dioxide, and then fumigated with an 80:20 mixture of carbon tetrachloride and carbon disulfide. Oxygen consumption declined 40 percent within 10 minutes. Beetles not preconditioned before being placed in sublethal concentrations of the same fumigant increased their respiration rate

within 20 minutes. During the next 40 minutes there was a gradual decline in respiration, which was still 50 percent below average 9 hours later. The fumigant was most effective against the insects when they were exposed at the time of low rather than high metabolic rate following preconditioning. Nitrogen is about twice as effective as carbon dioxide for preconditioning, and the minimum treatment period for effective results is 1/2 hour.

(MQ 1-31)

In studies to determine the influence on insects of clean grain and varying degrees of dockage up to 13.5 percent it was found that adults and larvae of the red flour beetles and the saw-toothed grain beetle were attracted to and produced more progeny in an environment having 4.5 percent dockage. However, the confused and red flour beetles and the saw-toothed grain beetles were able to survive and reproduce on clean wheat provided the moisture content was 14 percent. Although there was high mortality at reduced moisture content the wheat kernels were damaged. A large number of kernels damaged by the grain beetles looked sound, but X-ray examination showed the germ completely consumed and usually a considerable amount of endosperm also eaten away.

(MQ 0-0-1(CCC))

When the density of khapra beetle larvae exceeded about 150 per 3.5 grams of ground wheat, development was delayed, and the effect was greater in females than in males. Allantoin, urea, uric acid, and ammonia salts, materials found in larval excrement, did not affect development of the insects when fed in low concentration, but at 5-10 percent level in the diet, urea and allantoin delayed development. Wheat damaged by fungus or khapra beetle larvae was more attractive than sterilized wheat. Although fewer larvae survived on a diet of dried larvae than on ground wheat they were heavier and the adults developing from them produced more progeny. In the second generation development was more normal. In olfactometer studies with larvae a powerful natural attractant was detected which promises a new method of detecting infestations of this important grain pest in the quarantine effort.

(A10-AMS-11(k))

2. Insecticide Evaluation. Nearly 100 percent of test insects were killed in laboratory jar tests involving exposure to wheat of 12.5 percent or less moisture content treated with several diatomaceous earths, silica aerogels, and carborundums. Silica aerogels almost completely prevented development of progeny. The diatomaceous earths permitted a few more progeny to develop, especially of the lesser grain borer. Aging did not influence the effectiveness of the dusts at the temperature-humidity levels existing in the test. In other jar tests with treated grain, carbaryl was more effective on some insects than others, while diazinon and fenthion were more broadly applicable than malathion. One year after shelled corn was treated with 4 candidate protectants, fenthion gave higher residual toxicity than the malathion standard against adult rice weevils, and confused and red flour beetles. Diazinon was not as effective as fenthion and about the same as malathion. Dichlorvos and naled were effective for only a short time. In another test, carbaryl at up to 50 p.p.m. was not as effective initially as

was malathion at 10 p.p.m. Carbaryl was more effective against rice weevils and red flour beetles than against confused flour beetles. (MQ 1-15)

3. Insecticidal Control. Corn from 188 farms in Georgia, Alabama, and Mississippi averaged 19 insects per pint at harvest, and increased 7-fold in 1 year's storage to 151. Rice weevil comprised over 50 percent of all insects at harvest and over 70 percent after storage. The red flour beetle was a poor second at 7.5 percent. At harvest 12.2 percent of the kernels were infected and increased to 38 percent during 1 year of storage. Untreated ear corn showed 37.5 percent damage after storage, and shelled corn 51.9 percent. Fumigants and protectants were about equally effective on ear corn, and reduced damage by about one-third. With shelled corn, fumigants reduced damage by approximately one-fifth, and protectants by about one-half. Based on nutrient values, the loss in insect damaged corn at harvest in these 3 States was about \$4,000,000, and increased to \$10,000,000 by the end of the storage period, as indicated by the quarterly crop reports of corn in storage for these 3 States. (MQ 1-30(C))

4. Nonchemical Control. A field test of inert dusts applied to wheat and corn indicates that all dust treatments and the malathion standard have held insect populations well below those in the untreated checks. Test weight of the dust-treated grain was lowered several pounds per bushel, adversely affecting the grade. In a laboratory test with rice weevils in wheat treated with diatomaceous earth, survival of adults and production of progeny through 2 generations increased as moisture content of the wheat became greater. Over a 2-year period on shelled corn in flat storages fewer insects developed where aeration fans blew the air through the corn than in those where the fans pulled the air out. Two bins where the fans pulled the air had to be fumigated because of high rate of insect infestation. Horizontal aeration ducts in circular metal bins were more effective in controlling insects than were the vertical ducts. The bins without aeration and those having vertical ducts had to be fumigated during the first 18 months because of high insect populations. (MQ 0-0-1(CCC))

Infestation of pasta by the rice weevil occurs after manufacture rather than from infested grain. This is shown by the following facts: (1) The eggs are larger than the semolina granules used in making pasta; (2) all stages of the rice weevil placed in semolina were destroyed in the process of making pasta; and (3) examination of thousands of samples of pasta have revealed no infestation in the freshly made product. (E15-AMS-9(a))

5. Toxicology. Previous research showed that ethylene dibromide in the diet of laying hens caused a decrease in egg size or number of eggs, depending upon the amount ingested. Since ethylene dibromide adversely affected the metabolism of -SH groups and ascorbic acid, the effect was investigated of adding 0.06 percent of ascorbic acid or 0.6 percent of methionine to the

diet of hens also receiving ethylene dibromide. Ascorbic acid at this level increased the size of eggs but did not completely overcome the effects of ethylene dibromide. Cocks receiving low concentrations of ethylene dibromide from the first days of life overcame the effects, but most of those fed higher concentrations failed to produce fertile semen. Daily feeding of ethylene dibromide to bulls from birth produced sperm abnormalities. A similar effect was observed in a mature bull 2 weeks after ethylene dibromide was administered daily in the diet. There was recovery to normal 2 weeks after administration ceased. Young heifers given ethylene dibromide in the daily diet from time of birth gave evidence of difficulty in conceiving. It appears that the level of feeding used to produce these conditions is considerably above amounts of ethylene dibromide that would be expected from the normal use of this fumigant. This will be investigated further, along with the determination of the lowest levels of ethylene dibromide that will cause adverse toxicological effects. (A10-AMS-4(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation

Johnson, Robert M., Jackson, Ronald L. and Anzulovic, Bertha M. 1964. Microscopic identification of diatoms on treated wheat. *Agronomy Journal*, Vol. 56, p. 241. (MQ 0-0-1(CCC))

Prevention of Insect Infestation

McGregor, Harrison E. 1964. Preference of Tribolium castaneum for wheat containing various percentages of dockage. *Journal of Economic Entomology* 57(4): 511-513. (MQ 0-0-1(CCC))

dal Monte, Gino. 1964. Metodo per "liberare" le uova di punteruoli. (Method for separating the eggs of the rice weevil.) Estratto dalla Rivista "Molini d'Italia," No. 5, pp. 173-175, May 1964. (E15-AMS-9(a))

Quinlan, James K. 1963. Research activities on stored shelled corn at the Watseka, Illinois, experimental binsite. Abstract in Proceedings North Central Branch, Entomological Society of America, Purdue University, Lafayette, Indiana, March 20-22, 1963. (MQ 0-0-1(CCC))

Stanic, V., Shaaya, E. and Shulov, A. 1963. The effect of larval excrements on the growth of Trogoderma granarium (Everts). *Rivista di Parassitologia* 24(1): 13-17. (A10-AMS-11(k))

AREA 4a

RICE - MARKET QUALITY

Problem.

Milling is one of the important quality properties in determining the grade of rice. New and improved methods and techniques for measuring quality factors are needed to insure uniform products in marketing channels and more equitable prices to buyers.

Harvested rice is subject to damage or deterioration in quality while in marketing channels through normal metabolic changes, by the action of disease organisms, and by insect infestation. One major importing country has written officially to comment adversely on the amount of insect infestation in rice shipped from our Gulf ports. It is therefore apparent there is need for more effective ways of preventing insect infestation during storage, handling, processing, packaging, and transportation of rice. Attention must be given to developing methods that will minimize or eliminate pesticide residue hazards. To maintain the quality of this product, more precise information is needed on the changes that occur in handling, storage, and transportation. To insure uniform and standardized products and more equitable prices to all concerned, new and improved procedures for measuring quality factors must be developed for use in inspection, grading, and standardization operations.

USDA PROGRAM

The Department has a continuing program involving engineers, chemists, and plant pathologists in basic and applied research on the quality evaluation and quality maintenance of rice. This work is located at College Station, Texas, in cooperation with the Texas Agricultural Experiment Station, and Beltsville, Maryland.

The Federal scientific effort in this area totals 2 professional man-years: quality evaluation 1.0; quality maintenance in handling and packaging 0.5 and quality maintenance in storage 0.5.

Line Project MQ 3-12, "Develop a method for identifying varieties of long grain rice acceptable for use in routine inspection under U. S. Standards for rough, brown, and milled rice," was terminated during this period.

A grant with the Department of Plant Chemistry, Valencia, Spain, provides for a study on objective methods for measuring market quality of rice. Its duration was for 4 years, 1960-1964, and involved P. L. 480 funds with a \$19,390 equivalent in Spanish pesetas.

(E25-AMS-1)

A grant with the Department of Plant Chemistry, Valencia, Spain, provides for a study on storage changes in milled rice and their relation to market quality. Its duration is for 4 years, 1964-1968, and involves P. L. 480 funds with a \$62,479 equivalent in Spanish pesetas.

(E25-AMS-9)

There is a continuing program involving entomologists and chemists engaged in basic and applied research on the prevention of insect infestation in rice in the marketing channels, headquartered at Fresno, California. The Federal effort of about 2 professional man-years was temporarily diverted during this reporting period to emergency research on the effects of gamma irradiation on stored-product insects, which is also pertinent to the problems of insect infestation in stored rice. Much of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in stored rice.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations maintain a continuing but very modest program of research related to the market quality of rice. It involves evaluation of new rice varieties and lines for specific qualities through cooperation with the Regional Rice Quality Laboratory. Basic chemical and physical data relative to the quality of the rice and its protein, lipid and starch components is sought. The variation in these constituents among several varieties and in relation to maturity at harvest is also investigated. Another study is concerned with the effects of infrared drying of rough rice on the quality of the milled rice.

The total state scientific effort devoted to market quality research on rice is 1.6 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Long-Grain Milled Rice. A light reflectance technique which measures the degree of milling of rice in about 1 minute was developed.

The present official method for determining degree of milling and degree of parboiling in rice is based purely on a visual color comparison. During this study, it was observed that the degree of milling in parboiled rice was a hindering factor for the rice inspector in making the determination for degree of parboiling. Therefore, parboiled samples were remilled to remove any excess bran which might influence color. The degree of parboiling was then measured with the Agtron light reflectance instrument at 546 m μ . Although some of the values did not fall within the limits established for the visual grade, this light reflectance technique has the advantage of objectivity - it is not dependent upon the visual perception of an inspector. (MQ 3-12)

2. Objective Measurements for Determining the Degree of Milling of Rice. An experimental lightness meter designed for measuring the color of milled rice proved quite satisfactory. A correlation coefficient of 0.921 was obtained for the experimental lightness meter vs. visual degree of color. For measuring degree of parboiling, correlation coefficient was 0.740, somewhat lower than is desired. The Agtron color meter was also tested and proved satisfactory for measuring color of white rice ($r = 0.906$) but was unsatisfactory for measuring degree of milling ($r = 0.585$) or degree of parboiling ($r = 0.582$). (MQ 3-16(Rev.))

3. Chemical Indicators of Quality. There is a direct correlation between the protein content of the outer layer and rice quality. This is the basis of a method developed for measuring quality in more than twenty varieties, comprising over thirty rices from different crops and places. (E25-AMS-1(a))

B. Quality maintenance in handling and packaging

1. Microbiological, Chemical and Physical Deterioration of Rough Rice. Differences between Belle Patna rough rice infested with Penicillium puberulum and noninfested rice were not detected after incubation for 10 weeks at 15°, 20°, 25° and 30° C. A marked quantitative increase was observed in the Aspergillus candidus-infested rice incubated at 30° C for 10 weeks but no changes were observed in the infested rice incubated at 15°, 20° and 25° C. After 5 days, the dry mycelial weight of Helminthosporium oryzae averaged 34.5% of the initial rice solids in a ground rice medium and 39.2% of the solids were recovered from the medium, leaving a net dry matter loss of 26.3%. A. candidus required 15 days' growth before the net loss of solids reached the level obtained by H. oryzae in 5 days. Severe preharvest infection of Belle Patna rough rice by H. oryzae had no apparent effect on the rate of subsequent deterioration in storage at 30° C and 75% relative humidity. Invasion by storage fungi occurred at a slightly higher rate in the noninfested rice.

Four cultures of the Aspergillus flavus-oryzae group were isolated from rice and tested for the ability to produce aflatoxins on rice and peanuts. Two of the isolates were positive, producing aflatoxin B on both substrates.

(MQ 2-7(Rev.))

C. Quality maintenance in storage

1. Heat Damage of Rice. Inoculation of sterile rough rice with Aspergillus candidus and subsequent incubations at 30° C resulted in typical heat damage. The occurrence of heat damage was erratic and much less severe in the long-grain varieties; a subsequent additional incubation period of 7 days at 45° and 50° C increased its prevalence by factors of 7.3 and 9.5, respectively.

(MQ 2-76)

2. Damage and Off-Color in Rough Rice. Helminthosporium oryzae was shown to be the cause of the high incidence of damage, "pecky kernels" in par-boiled rice, that was observed in the 1963 second-crop Belle Patna rice. This particular type of damage occurs prior to harvest and does not increase in severity after harvest in rice with a moisture content of less than approximately 20%. No differences in susceptibility between Belle Patna and Blue Bonnet 50 were detected by laboratory inoculations of sterile rough rice. Because of the prevalence of H. oryzae infection of rice kernels, it is a major cause of "peck" in parboiled rice.

(MQ 2-77)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Casas, A., Barber, S., y Castello, P. 1963. Factores de calidad del arroz. X. Distribucion de grasa en el endospermo. Publicado en la Revista de Agroquímica y Tecnología de Alimentos Vol. 3, n.º3, Pag 241, julip-septiembre. 1/

Primo, E., Casas, A., Barber, S., y Villagrasa, J. 1963. Factores de calidad del arroz. XI. Efecto de la eliminacion de capas sucesivas del gravo sobre las características del arroz. Publicado en la Revista de Agroquímica y Tecnología de Alimentos Vol. 3, n.º3, Pag 245, julip-septiembre. 1/

Quality Maintenance in Storage

Schroeder, Harry W. and N. S. Evatt. 1963. Milling quality of rice as affected by nitrogen fertilization, variety, and method of drying. International Rice Commission News Letter. XII (2):1-7.
(MQ 2-7(Rev.))

Schroeder, Harry W. and D. W. Rosberg. 1964. Effect of infrared intensity on drying Rexoro rough rice. Rice Jour. 67(3):28, 29, 37, 41-43.
(MQ 2-7(Rev.))

Schroeder, Harry W. 1964. Communication to the Editor: A cause of damaged and pecky rice. Cereal Chem. 41:122-124. (MQ 2-77)

Schroeder, Harry W. 1964. Grain discoloration in Belle Patna rice. Plant Disease Reporter 48(4):288-291. (MQ 2-77)

Prevention of Insect Infestation

Cogburn, Robert R. and Elvin W. Tilton. 1963. Studies of phosphine as a fumigant for sacked rice under gas-tight tarpaulins. Jour. of Economic Entomology 56(5):706-708. (MQ 1-3)

Stored-Product Insects Branch. 1963. Insect prevention and control in rough rice. USDA Marketing Bulletin No. 28, 7 pp. (MQ 1)

Stored-Product Insects Branch. 1964. Controlling insect pests of stored rice. Agriculture Handbook No. 129, Revised July 1964, 28 pp. (MQ 1)

1/ These publications resulted from work under P. L. 480 grant E25-AMS-1(a).

Tilton, Elvin W. and Robert R. Cogburn. 1964. Laboratory evaluation of Bayer 29493 used for the protection of rough rice against insect attack. Proceedings, Rice Technical Working Group, Davis, Calif. June 17-19, 1964. (MQ 1-15)

Tilton, Elvin W. and Harry W. Schroeder. 1963. Some effects of infrared irradiation on the mortality of immature insects in kernels of rough rice. Jour. of Economic Entomology 56(6):727-730. (MQ 1-9)

AREA 4b

FEED AND SEED - MARKET QUALITY

Problem.

It is generally conceded that most methods of determining seed quality are out dated. The methods currently in use require too many man-hours, impose tedious work on the analyst, are incapable of high degrees of standardization, do not provide accurate indexes of quality, or necessitate undue delays in providing test results. The more important quality factors for which improved testing methods are needed include: mechanical purity, genetic purity, germination, vigor, weed seed content and infection with disease organisms. Satisfactory methods of testing the seed of some of the new species of range grasses and legumes are needed. There is no acceptable method of testing seeds for vigor except the cold test for corn. There is urgent need to conduct basic research to serve as a basis for developing more practical methods of determining seed quality and for recommending improved practices of storing seed. Of immediate need are methods for testing range grass seeds, determining seed and seedling vigor and identifying crop varieties by seed characteristics (genetic purity).

USDA PROGRAM

The Department has a continuing long-time program on seed research involving botanists, plant physiologist, plant pathologists, engineers, and chemists engaged in both basic and applied research on quality evaluation and quality maintenance of seed. This research is conducted at Beltsville, Maryland, and College Station, Texas, and by research contract with the Oregon Agricultural Experiment Station.

A P. L. 480 grant with the Instituto Biologico, Sao Paulo, Brazil, provides for a study of substrate moisture levels for germination testing of agricultural seeds. The project runs from 1962 to 1967 and involves \$31,016 equivalent in Brazilian cruzieros.

A P. L. 480 grant with Rijksproef-station, Wageningen, Netherlands, provides for a study of the health condition of seeds in commercial channels and development of methods suitable for routine testing for seedborne organisms. The duration of the project is 5 years, beginning 1963 and the total grant in Dutch guilders is the equivalent of \$55,777.

A P. L. 480 grant with the Israel Institute of Technology, Haifa, Israel, provides for a study to develop tests for nutritive value of cereal grains and feeds. Its duration is 4 years, 1960-1964, but an extension of an additional year has been approved. The project involves an expenditure of \$31,016 equivalent in Israeli pounds for the original 4-year period.

The Federal scientific effort devoted to research in this area totals 8.0 man-years of which 2 man-years are by research contract.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Scientists at the state stations have engaged in the study of the market quality of feed and seeds for many years. The program is continuing and involves both basic and applied research.

Much of the research on feed quality is conducted in conjunction with the extensive program in animal nutrition. Quality of feed studies relate to determining keeping quality of feeds as influenced by methods of harvesting, storing and handling of livestock feeds. Mechanical developments facilitating the mechanization of harvesting and handling feeds have led to consideration of alternate feed handling and storage methods and evaluation of their effects on feed quality. Attempts to store feedstuffs with a minimum loss of quality and nutritive value have led to study and development of routine methods for evaluation of vitamins A and D in feeds. Biological changes occur in feeds during storage and the relationship of these changes is related to deterioration in quality and nutritive value. Other research is directed to studies of computer formulated, least cost feeds with quality and nutritive value considered as important factors.

Seed quality research involves physiological studies on factors associated with seed deterioration, the sequence of biological changes in storage, storage factors affecting these changes, seedborne microflora, and the use of seed coatings to preserve quality. Testing procedures for germination, vigor and stand-producing potential are receiving much research effort. Other work is being done on blending seeds for uniform quality.

Two regional projects have been organized by the states to coordinate research on seed problems, including quality considerations. In the Northeastern region under NCM-22, quick methods of determining varietal purity of alfalfa and red clover are sought through both field and laboratory experimentation. In the Western region under WM-35 much attention is given to developing and improving techniques for rapid estimation of such quality factors as viability of seed, germination and purity.

The total research effort in this area is 20.6 professional man-years, of which 1.7 is devoted to feed quality research, and 18.9 professional man-years is devoted to study of post harvest physiology of seeds and objective measures of quality in seeds.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Mechanization of Purity Analysis. The semi-automatic inspection station and treated seed inspection station referred to in the 1963 report have required several alterations which demanded much of the engineer's time. A new feeder was developed, based on a different principle. Instead of a belt, vibrators were used to move the seed forward in a controlled band. A fused opal glass diaphanoscope was incorporated into the inspection station. This permits the analyst to determine quickly whether grass "seeds" are filled or contain caryopses. An indent cylinder machine capable of handling laboratory samples was designed and constructed. A small blender and subsampler making use of an air stream to mix the seeds was constructed. (MQ 3-21(c))

2. Measuring Seed Moisture Content. Studies carried out on 4 species of grass seeds, 1 species of vegetable seeds and 4 species of tree seeds indicate the feasibility of using the Motomco electronic moisture meter in determining moisture content when the requirements of accuracy are not exacting. Tentative calibration charts have been prepared for all of these seeds. A paper describing this work is being prepared for publication. (MQ 3-23)

3. Seed Metabolism. Systems responsible for protein synthesis were studied in wheat embryo, lima bean axis, and peanut cotyledon. During imbibition these systems are transformed from nonfunctional to functional. By breaking the systems down to smaller components, it was shown that the imbibitional transformation occurs in only one component, the ribosome. Under functional conditions, the latter binds messenger RNA forming a polysome. In the unimbibed state the ribosome occurs without messenger RNA.

Viable wheat embryos treated at 50° for 1 hour and untreated commercial wheat embryo are unable to develop capacity for protein synthesis. Cold damage in lima bean axes sharply reduces their ability to develop a functional system for protein synthesis. These findings indicate that the above process is a very sensitive phase of germination.

(MQ 3-32)

4. Determining the Purity of Certain Grass Seeds. Tests of various mixtures of a large number of solvents suitable for making a purity analysis of grass seed by flotation methods were made. The results show that a mixture of carbon-tetrachloride and hexane gives best results in accuracy of analysis with lowest detrimental effect on germination. Extensive tests of the accuracy of results obtained show a standard error of 0.839 by flotation analysis as compared to a standard error of 0.619 by hand analysis of dallisgrass. Additional significant results show that (1) equally good results are obtained by the flotation analysis for all levels of purity, (2) complete removal of the solvent prior to planting or wetting with water is essential to minimize the effect on germination, and (3) the flotation analysis appears to be suitable for all grass seeds which are or can be made relatively free-flowing. Some kinds of seeds successfully analyzed to date include bahiagrass, dallisgrass, orchardgrass, Kentucky bluegrass and smooth brome. Development of mechanical equipment (Proj. MQ 3-54) will extend the application of this technique to many other grasses.

(MQ 3-39)

5. Hay Moisture. A moisture meter for grass and legume hay has been developed and field tested. The meter utilizes the electrical conductance principle for determining moisture content. The conductance is measured between four $\frac{1}{2}$ -inch brass pins mounted 2 inches apart on a 1.414-inch radius on a plastic disk. The disk is used to compress a 250 to 300 gram (dry weight) sample of hay in a 5-inch cylinder. Measurements are made between the pins protruding into the compressed sample. The meter is portable and fast. Only 2 to 3 minutes are required for a moisture determination. Correlation between the meter reading and oven was very good (0.94) for 50 samples (varying in moisture content from 10 to 45 percent) drawn from field windrows. The standard error of estimate was ± 2.00 percent moisture.

(MQ 3-41)

6. Development of Seed Germinator. The basic germinator under development consists of a cabinet having a stainless steel interior with dimensions of 2' x 2' x 4' and a capacity of 16 - 20" x 20" seed trays. This is the size of greatest demand in seed testing laboratories. Cooling of the germinator is accomplished by circulating cold water through two banks of cooling coils, one on the back wall and one on the door. Heating is provided by a 750 watt immersion heater which also maintains a high relative humidity at all times. An electronic thermistor actuated controller was designed especially for temperature control. The germinator will maintain any temperature between 15 and 35° C. or may be set to automatically alternate between any two temperatures within this range.

The temperatures are easily changed by setting two dial switches to the desired temperatures, one for the low cycle and one for the high cycle. Lighting is provided by eight 15-watt fluorescent lamps mounted on the outside of thermopane windows on each side. Other designs of lighting are under consideration for more uniform distribution. Performance data indicates that the maximum temperature variations from one location to another is $\pm 0.75^{\circ}\text{C}$., and maximum variation from one time to another is $\pm 0.5^{\circ}\text{C}$.. The rate of change from one temperature to another is about 20°C . per hour.

(MQ 3-48)

7. Processing Grass Seed for Laboratory Testing. This project covers research to develop techniques and/or devices to facilitate handling of certain grass seeds having characteristics that interfere with rapid handling and accurate testing for purity and germination. Certain kinds of grass seed prove very difficult to handle because of seed appendages, multiple florets, or other characteristics which prevent them from flowing freely. Efforts to date have been concentrated in developing a technique for the separation of multiple florets into single florets. Consideration has been given to the possibility of shelling the seeds from the glumes as this appears to be easier to accomplish. The devices tested thus far include a hammer mill, laboratory debarker, and a modified McGill rice sheller. Of these, the modified rice sheller equipped with a set of interchangeable rollers appears to offer the best possibilities. The depth and width of flutes on the rollers varies to permit selection of the proper size for a given kind of grass. The rice sheller has also been equipped with a continuously variable speed drive to permit studying the effect of various operating speeds.

(MQ 3-54)

8. Seed Vigor. Attempts are being made to develop a rapid and quantitative physiological test for seed vigor in corn. The problem has been attacked by comparing seed respiration, prior to radicle emergence, with seedling growth during the following two or three days and by comparing early growth rates in an incubator with growth under greenhouse or field conditions. Respiration rates one day after planting are positively correlated with subsequent seedling growth, especially that of the shoot. The degree of correlation is higher in fast-growing than in slow-growing seedlings and is lowered by growth-inhibiting doses of gamma-irradiation. Pre-sowing treatments with irradiation or heat which reduced vigor, also inhibited seed respiration. The results suggest that respiration measurements might detect heat damage even when the degree of injury is so slight as to escape notice by standard germination tests. A "respiration test" for seed vigor, if successfully developed, would offer a number of advantages over those presently employed. Respiration can be measured quantitatively under standard conditions. It can be measured within a few hours after planting. Such a test is very flexible regarding sample size and can be used to measure samples ranging from individual seeds to hundreds of seeds. Many replicates can be run simultaneously. Because respiration is measured under

conditions favorable for germination, seeds may be replanted for a direct comparison with germination tests.

A preliminary investigation is underway to determine if a correlation may exist between the results obtained in the conventional cold test for corn seed and the reaction of corn seed to culture filtrates produced by fungi pathogenic to corn. Filtrates produced by several species of Helminthosporium and Fusarium have been tested against samples of corn seed of which the cold test results are known. These seed have been grown on blotter substrates in plastic Petri dishes and allowed to imbibe filtrate. Measurements have been made of their respiration and root and shoot length and compared to the cold test results. However, our data so far indicate no correlation between performance of a sample of corn seed in a cold test and their performance in our filtrate test. (MQ 3-55)

9. Varietal Identification of Crop Seeds. The object of this project is to determine whether biochemical procedures can be used to distinguish or identify crop varieties. Soybean is being investigated initially. Preliminary results strongly suggest the feasibility of distinguishing soybean varieties by this procedure. (MQ 3-64)

10. Development of Methods Suitable for Routine Testing of Seedborne Organisms. This P. L. 480 project, assigned to the Dutch seed testing station, Wageningen, Netherlands, was activated approximately January 1, 1964. There had been a six-month delay in staffing as the project leader had the opportunity of employing a young man who finished his university training at the end of 1963 and had previously had some work experience in Canada. No progress report has been received yet. (E19-AMS-11(a))

11. Moisture Levels for Seed Germination. Research aimed at finding optimum moisture content of seeds for germination and for providing test conditions that will insure optimum moisture is being continued under a P. L. 480 project in Brazil. The principal findings reported thus far are: (a) Optimum germination is attained over a range of moisture percentages rather than at a single moisture content of the seed; (b) addition of water in excess of this maximum resulted in some abnormal seedlings in the case of Macuna (Stizolobium atterinum) and grandu (Cajanus cajan); (c) seeds exposed to moisture levels near the center of the accepted range germinated slightly better and developed into more vigorous plants than when exposed to moisture levels near the limits of the range; (d) a better moisture relationship was maintained by placing the seeds between substrates

(blotters and vermiculite) than when placed on top of the substrate; and (e) moisture uptake is more closely correlated to seed weight than to number of seeds.

(S3-AMS-2(a))

B. Quality maintenance in storage

1. Deterioration of Grass Seed. Seeds of Kentucky bluegrass, red fescue, tall fescue, and annual ryegrass have been in storage since January, 1964, at 16 levels of temperature - relative humidity. Subsamples removed at intervals of 2 months and 4 months were tested for infection by storage fungi, germination percent, and moisture content. Data obtained so far show that the grass seeds stored at high relative humidity (95 percent) and high temperature (35° C.) for 2 months suffered a severe decline in germination. This decrease in germination apparently was not correlated with infection by the storage mold, Aspergillus amstelodami.

Noninoculated seeds stored at high levels of temperature (30° and 35° C.) and relative humidity (75 and 95 percent) for 2 months were found to yield high percentages of storage fungi, principally A. amstelodami. This occurrence is unexplicable at the present time because:

- (a) The seeds which came from samples tested on 10 percent salt-malt agar just prior to setting up the experiment, were shown to be completely or almost completely free of externally and internally-borne storage molds.
- (b) Precautions were taken to insure that the noninoculated (check) seeds were not contaminated with storage fungi either during the setting up of this experiment or during subsequent sampling and testing.

(MQ 2-62)

2. Seed Irradiation. Samples of 8 kinds of agricultural and vegetable seeds were irradiated in an exploratory study with gamma rays from a Co⁶⁰ source to study the effects of irradiation on seedborne storage fungi and on seed germination and storage life.

(MQ 2-)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Andersen, Alice M. 1963. Germination of seed of Texas needlegrass, Stipa leucotricha. Proc. Assoc. Offic. Seed Anal. 53:74-79.

(MQ 3-19)

Andersen, Alice M., J. R. Hart and R. C. French. 1964. Comparison of germination techniques and conductivity tests. Proc. Internat. Seed Test Assoc. 29(1):81-96.

(MQ 3-19)

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(MQ 3-23)

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Justice, O. L. 1964. Uniform classification of weed and crop seeds. Assoc. Offic. Seed Anal., Handbook (1964). 33 pp.

(MQ 3-64)

Justice, O. L. 1964. The fluorescence test for ryegrass. Assoc. Offic. Seed Anal. Handbook (1964). 10 pp.

(MQ 3-64)

Kulik, M. M. 1964. Relationship of fungi to fluorescence in wheat. Plant Disease Reporter 15(4):283-285.

(MQ 3-)

Kulik, M. M. and W. F. Crosier. 1964. Microbiologic assay of fungicide-treated seeds. Assoc. Offic. Seed Anal., Handbook, Contr. No. 26. 8 pp.

(MQ 3-)

Marcus, A. and J. Feeley. 1964. Activation of protein synthesis in the imbibition phase of seed germination. Fed. Proc. 23:268.

(MQ 3-32)

AREA 5

LIVESTOCK AND MEAT - MARKET QUALITY

Problem.

Meat is a very perishable commodity which varies greatly in quality characteristics such as tenderness, juiciness, flavor and fat content. To the consumer the visual characteristics of meat quality are primarily color and fat-to-lean ratio. However, properties such as tenderness, juiciness and flavor cannot be judged so simply. The meat grader attempts to evaluate these quality factors by relating quality to evidences of maturity, texture of the lean, and degree of marbling. To insure more uniform grades and standardized products, better objective tests for measuring the quality attributes of tenderness, juiciness and flavor in meat are needed. Also needed are more effective methods for maintaining optimum quality by minimizing such deleterious effect as shrinkage and bloom and by enhancing the shelf-life of meat as it moves through market channels.

USDA PROGRAM

This work is being conducted at Beltsville, Maryland, with the cooperation of the Animal Husbandry Research Division, ARS, the Livestock Division, AMS, and in part by research contract with the University of Missouri and by cooperation with the University of Illinois. Research programs concerned with the development of new techniques for measuring meat tenderness and for evaluating the composition of livestock, carcasses and meat cuts are underway. The application of the ultrasonic technique to estimate the thickness of backfat and muscling in live hogs, cattle, and sheep is one example of this type of research. Another area of interest is concerned with the use of improved sanitary practices in the merchandising of meat to extend shelf-life and to develop objective methods for the evaluation of quality and shelf-life of prepackaged fresh meats. Studies are also underway to standardize lighting conditions in work areas where meat grading is done.

To augment in-house research at Beltsville a new meat laboratory has been established. Here instrumental techniques in conjunction with classical methods of organic and biochemistry are applied to problems concerned with the evaluation and maintenance of meat quality. Basic information gained at the molecular level concerning proteins, electrolytes, phospholipids,

triglycerides and other meat constituents will be used in attempts to establish objective methods for quality evaluation.

A grant with Robert College, Istanbul, Turkey, provides for the development of an odor-measuring instrument for use in inspection and grading of foods. Its duration is for 5 years, 1961-1966, and involves P.L. 480 funds with a \$29,361 equivalent in Turkish liras.

A grant with the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide or nitrogen on refrigerated meat. Its duration is 4 years, 1963-1967, and involves P.L. 480 funds with a \$44,453.40 equivalent in Finnmarks.

The USDA scientific effort devoted to research in this area totals four professional man-years of which one man-year is on contract and 2.5 man-years are in the area of objective measurement and evaluation of quality.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research directed to increasing our understanding of the market quality of meat has been a continuing part of the State stations' research program. Both basic and applied research are involved.

Market quality research on meats begins with study of the influence of breeding, feeding and management treatments with cattle, sheep and swine on the carcass and meat quality characteristics. The objective is to determine the relationships of live animal and management factors to ultimate eating quality. Such live animal traits as birth weight, rate of gain, efficiency of gain by sire groups, body measurements such as depth and length of body, type, market weight and grade are related to carcass traits such as loin eye area, muscling characteristics, amount and distribution of fat, yield of wholesale cuts, chemical composition and carcass value in an effort to define animal traits which influence carcass and meat quality.

Other research involves investigation of various pre-slaughter treatments on the carcass quality, organoleptic characteristics and market value of the meat. Special attention is given to tenderness of meats and the fundamental causes of toughness or tenderness in meats. Certain post-mortem factors including aging exert profound effects on meat quality and considerable effort is devoted to attempts to gain a better understanding of their effects.

Almost all of the studies involve a certain amount of work on methods since methodology is of vital importance in the study of quality factors. Development of objective criteria for evaluation of meat quality is a continuing

goal and new and improved methods of defining the quality of meat cuts are constantly sought.

Further along the route to the consumer, concern arises as to the effects of processing and storage treatments on the quality of meat. The influence of maturity, marbling, methods of aging and processing and storage, packaging and distribution are all studied for possible effects on ultimate quality. Microbial quality, distribution of muscle proteins and lipids, morphological features, amount of connective tissue, and cooking treatment are other factors considered in attempting to establish the total quality characteristics of meat. Finally, the relationships of raw and cooked meat quality to consumer preference are determined. These are in turn related to the carcass quality and market value of the live animal.

A total of approximately 17.7 professional man-years are devoted to market quality research on meats.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Yield of Lean Meat from Cattle of Different Conformation. The study in cooperation with the Livestock Division and the University of Illinois comparing two groups of cattle of different conformation but of the same USDA Quality Grade (Choice) has been completed. Results showed that there were no differences between the yield of lean meat from these two groups of beef carcasses when evaluated according to the system of determining yield developed by USDA. Palatability studies comparing these two groups of carcasses showed no difference in eating quality as judged by a six-member taste panel or by Warner-Bratzler shear determinations. Analysis of the beef carcass data in order to develop correlations and multiple regression equations that can provide guidelines to measurements that account for the greatest amount of variation in yield of lean meat from these wholesale cuts have also been completed.

(MQ 3-34)

2. Measurement of Tenderness. In a study being conducted cooperatively with Animal Husbandry Division the tenderness of cooked loin steaks and rib roasts of beef, representing a range in carcass grade from Utility to Choice are being measured. Subjective tenderness evaluation data are being obtained by taste-panel judgements; objective measurements by Warner-Bratzler shear determinations and measurement on puncture and shear using the Slice-Tenderness Evaluator (STE) developed by USDA. This phase has not reached the stage for reporting findings.

(MQ 3-34)

3. Relationship of Marbling to the Palatability of Beef. This project has been initiated to study the relationships between marbling and composition, concentration and distribution of lipid material in beef muscle. Marbling plus this type of knowledge, or this information alone, may provide a more object method for the evaluation of palatability than marbling per se. This project is in its initial stages and no findings can be reported.

(MQ 3-60)

4. Flavor Studies to Provide a Basis for More Objective Measurements of Meat Palatability. This project has been initiated to develop objective procedures for identifying and evaluating flavor characteristics of meat by studying the compounds and precursor systems responsible for meat flavor. Studies on beef and lamb are underway. A fraction has been isolated from unheated lamb fat that possesses characteristic lamb aroma. This crude fraction has been partially separated and procedures for the quantitative collection of these sub-fractions developed.

(MQ 3-61)

5. Objective Methods for Measuring Maturity. Stages of physiological maturity should be reflected in differences that can be measured at the molecular level in muscle tissue. A comparative study of the proteolytic activity of tissue, from similar muscles, from animals of different chronological age has been initiated in order to see if this measure of enzymatic activity can be correlated with maturity. New analytical procedures are being now developed in order to carry out the objectives of the research project.

(MQ 3-62)

6. Odor-Measuring Instrument. This project covers research being undertaken in Turkey under P. L. 480 funds. The investigator came to the United States and discussed the development and research basis for his instrument at a scientific meeting held in Washington on odor measurement.

(A22-AMS-1(a))

B. Quality maintenance in handling and packaging

1. Shelf-life of Prepackaged Meats. The University of Missouri has completed several storage cycles for beef and pork, under the contract, to study the factors affecting the shelf-life of prepackaged meats. Each cycle included different sanitation levels under controlled cutting room temperatures. As a result of this work a revised manual containing new recommendations for temperature, humidity, sanitation and handling procedures for fresh meats is being prepared.

(MQ 2-75)

C. Quality maintenance during transportation

1. Effect of Atmospheres of Carbon Dioxide and Nitrogen on Properties of Refrigerated Meat. The first annual report (covering period April 1, 1963 - March 31, 1964) was received under this P. L. 480 research grant. During the report period only one test series with meat kept in normal atmosphere was carried out. The greater part of the report period was consumed in procuring equipment and in trial runs and in developing the chemical and bacteriological methods of analysis.

(E8-AMS-5(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

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Feinstein, Louis and Richard L. Hiner. 1963. Anesthesia and its relationship to body composition. Annals of the New York Academy of Sciences 110:1141-1145. (MQ 3-34)

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AREA 6

OILSEEDS AND PEANUTS - MARKET QUALITY

Problem.

Harvested oilseeds and peanuts are subject to deterioration in quality and loss in value through insect and fungus attack and contamination, development of mycotoxins, normal metabolic changes, and instability of their oil constituents to atmospheric oxygen. To maintain the quality, more precise information is needed on the biology, ecology, and control of the various insects and fungi that attack oilseeds and peanuts; and on the physical and chemical changes and the environmental factors which influence these changes during handling, storage, transportation, and processing. Recent problems with aflatoxin and with insects developing resistance to protective pesticidal treatments suggest the desirability of a complete reevaluation of handling and storage methods for farmers' stock peanuts. Attention should be given to developing new procedures that would avoid the problems associated with fungi, insects, and pesticide residues. Also, to insure uniform and standardized products in the marketing channels, new and improved methods and techniques for measuring quality factors need to be developed for use in inspection, grading, and standardization operations.

Peanut flavor is subject to deterioration while in the marketplace through improper aeration, drying, handling and storing. Earlier studies conducted on the effect of artificially drying on peanut flavor and quality have not been conclusive. In addition, studies on shelling of farmers' stock peanuts have been initiated and there is need to determine the effect of variables in the drying and shelling operations.

USDA PROGRAM

The Department has a continuing program involving engineers and chemists engaged in basic and applied research on the quality evaluation, quality maintenance, and development of objective methods of quality evaluation of peanuts, soybeans, and other oilseeds. Research on soybeans is conducted at Washington, D. C., research on peanuts is done at Washington, D. C., Beltsville, Md., Raleigh, N. C., in cooperation with the North Carolina State College and Federal State Inspection Service, at Albany, Ga., in cooperation with the University of Georgia, and also has an agreement with the Agricultural Experiment Station of the University of Georgia at

Experiment, Ga., for making taste panel evaluations of cured peanuts, and by research contract with Texas A & M, College Station, Tex.

A 4-year study of storage changes which is being made at the College of Agriculture, Olsztyn, Poland, will be completed in 1964. This P. L. 480 grant provides an equivalent in Polish zlotys of \$18,127.00.

Under a P. L. 480 grant with Universita Di Firenze, Instituto di Industrie Agrarie, Florence, Italy, the second of a five-year study was completed on the effect of containers on long time storage of edible oils and the effect of certain natural and synthetic antioxidants on the oil during storage. This study involves P. L. 480 funds with an equivalent of \$26,344.61 in Italian lire.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years. Of this number 5.0 are devoted to quality evaluation and 1.0 to quality maintenance.

The Department also has a continuing program at Tifton and Savannah, Ga., involving entomologists and chemists engaged in basic and applied research on problems of insect infestation, damage, and contamination, and of pesticide residues in peanuts in the marketing channels. The research is conducted in cooperation with the Georgia Agricultural Experiment Stations, the Agricultural Stabilization and Conservation Service, the Transportation and Facilities Research Division, the Field Crops and Animal Products Branch, growers' cooperative associations, and various industry groups.

The Federal scientific effort devoted to entomological research on prevention of insect infestation totals 3.0 professional man-years. In addition, much of the cross-commodity research at Savannah, Ga., reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the problems in stored peanuts.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

A considerable amount of the genetic, breeding, variety and cultural research on oilseeds and peanuts has the ultimate objective of increased market quality. Other studies are generally directed to determining the influence of variety, stage of maturity and harvesting and handling practices on the market quality of the oilseed crop.

In the case of peanuts, the breeding objectives relate to yield, disease and insect resistance, local adaptation and trueness to market types. Studies more directly related to quality are concerned with the effects of

fungi on market value of the seeds and the fermentation products produced by fungi growing on peanut substrates. Market quality studies relate to effects of mechanical harvesting and curing, temperature-time-moisture relationships on keeping quality and on the market value of peanuts as affected by changes in storage. The quality of processed peanut products is being studied and the relationship of maturity and curing practice to finished product quality is being determined.

Research which relates to the history and control of insects affecting peanuts, soybeans and other oilseeds is reported in Area 13. Factors which affect soybean quality are involved in such breeding program objectives as improved resistance to disease, high oil content and seed quality. Illinois is evaluating the quality of soybeans and soybean products for human consumption. Missouri is researching genetic and environmental factors which affect the market value and quality of soybean seed for planting. Other research is directed to solving problems associated with storage and handling of oilseeds. For example, developments in the mechanization of castor bean production and handling are being investigated. Along with developments on production, state stations study the effects of conditioning and storage upon market value.

Total market quality research effort on peanuts and oilseeds at the state stations is approximately 6.7 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Methods and Equipment for Grading Farmers' Stock Peanuts. Studies on sampling shelled peanuts from bags have shown that a considerable percentage of the splits found in grading samples are caused by drawing samples from the bags with a seed trier. It was also shown that the seed trier draws the sample from the periphery of the bags and very few if any kernels from the center of the bags. Tests have shown that the percent of splits caused by the trier can be greatly reduced by inserting the trier only three or four inches into the bag and catching a grading sample after discarding the first 100 grams of kernels that flow from the trier.

Studies on the respiration of peanuts during the curing process have demonstrated that there is a correlation between off-flavor in peanuts and anaerobic respiration. The results strongly suggest a relationship, the exact nature of which is as yet undetermined.

A study of the effects of windrow orientation on the quality of peanuts indicates that plants in a windrow can be inverted so that the peanuts are exposed to solar radiation without significantly reducing milling quality or producing off-flavors. Peanuts exposed to the sun, dry more rapidly, and can be harvested more quickly after digging. The study also indicates that the amount of visible damage and field losses caused by inclement weather can be reduced by inverting the plants and harvesting the peanuts with above 20 percent moisture. (MQ 3-29)

2. Evaluation of Damage Factors in Peanuts. Twenty-one volatile compounds were isolated and separated from off-flavor peanuts. Eleven of the twenty-one are formaldehyde, acetaldehyde, ethanol, acetone, isobutyraldehyde, ethyl acetate, butyraldehyde, isovaleraldehyde, 2-Methyl valeraldehyde, methyl butyl ketone and hexaldehyde. Of the remaining ten compounds, one has been identified as either 2-Methyl 1-butanol, or 3-Methyl 1-butanol, one has been tentatively identified as furfural, one has been assigned a ketone functional group and the remaining seven compounds remain completely unidentified. Studies indicate that high temperature off-flavor is due to an enzymatic and/or sporogenic process. It has also been shown that this process is not inactivated by the curing treatment.

Taste panel evaluations and skin slippage tests were made on a series of samples which were cured at temperatures of 125°, 135°, and 145° F. Results show a definite trend toward flavor deterioration as the curing temperatures increased. Also as the harshness of the treatment increased the flavor deteriorated. The skin slippage tests indicated that higher drying temperatures and harsher treatments increased the amount of skin slippage.

Moisture distribution measurements made on the mechanically cured peanuts, indicated that the skin moisture of the peanuts is related to the maturity. Further testing with this technique will be carried out.

(MQ 3-26(c))

B. Quality maintenance in storage

1. Flaxseed Storage. A study under a P. L. 480 grant in Poland on the influence of storage changes on the quality of flaxseed and the quality of linseed oil has been under way three years. Initial tests have been made on flaxseed and linseed oil extracted from the seed and comparisons will be made at 2-month intervals during one-year's storage. (E21-AMS-6)

2. Soybean Oil Storage. All tests originally planned in this project have been completed. Statistical analyses of the data do not indicate significant relationships between the original oils and the quality changes taking place during storage. Loss of antioxidants and increases in secondary oxidation products will now be determined. (MQ 2-44)

3. Natural Antioxidants in Vegetable Oil Storage. About one-third of the samples being held at six constant temperatures (from 70-120° F) are now being tested for possible change in quality. These samples include refined and crude cottonseed, soybean, corn and safflower oils, as well as mixtures.

Preliminary results indicate the efficacy of the gossypol content of the crude cottonseed oils and the tocopherol content of the cottonseed and soybean oils in delaying the oxidation reaction at the different storage temperatures. It appears that such measurements on the original oils, along with determinations of primary and secondary oxidation products, will enable predictions to be made of possible quality changes in the major vegetable oils during commercial storage conditions. (MQ 3-25)

4. Vegetable Oil Storage. During the second year this P. L. 480 grant in Florence, Italy, covered the storage of oils held at 30° C and 40° C for a period of up to 257 days. Little change was noted in quality at 40° C for raw and refined peanut oils. Only minor changes were observed in the crude and refined olive oils. However, there was a significant decrease in quality of refined soybean oil and some decrease in quality of crude soybean oil. At 30° C, there were insignificant changes in all oils except refined soybean oil, where oxidation changes were evident. (E15-AMS-12(k))

C. Prevention of insect infestation

1. Insecticide Evaluation. Laboratory tests were conducted to evaluate potential protectants applied on farmers' stock peanuts. Fenthion gave greater immediate toxicity to the normal laboratory strain of the confused flour beetle than did the standard malathion treatment. Compounds less effective than malathion were diazinon, dichlorovos, naled, and carbaryl. (MQ 1-15)

2. Insecticidal Control. Laboratory dosage-mortality studies with methyl bromide established that 6.2 to 13.3 mg./liter in shelled peanuts and 6.4 to 9.5 mg./liter in farmers' stock peanuts killed 95 percent of red flour beetle adults and larvae and Indian-meal moth larvae exposed 24 hours at 80° F. The moth larvae were most susceptible, followed by red flour beetle adults, and the beetle larvae were most resistant. (Exploratory)

Observations in peanut shelling plants have revealed many sources for insect infestation. Most could be eliminated by a diligent sanitation program combining good housekeeping and the use of residual sprays. It appears that most of the insects infesting farmers' stock peanuts received at the shelling plant are removed by the cleaning steps of the shelling operation. This puts most of the responsibility for providing insect-free shelled peanuts directly upon the shelling plant operator. Observations of

several methyl bromide fumigations of shelled peanuts in trucks and rail cars revealed a number of improper or inadequate procedures responsible for poor results.
(Exploratory)

Observations in farmers' stock peanut warehouses showed the almond moth to be the predominant insect. Even though moths were present in a number of warehouses, the malathion surface sprays were holding insect damage to a very low level. Probe samples analyzed for malathion residue contained considerably more malathion than did samples last year. The residue on the shelled nuts was well under the tolerance level. An experiment to determine the loss of malathion resulting from varying degrees of handling treated nuts through commercial conveying equipment did not reveal any significant loss from such handling. The greatest and most rapid depletion of malathion deposit occurred during the first two or three months of storage.
(Exploratory)

Moths and beetles collected from warehouses where malathion had been used for one to five years were tested for resistance. A twenty-fold resistance to malathion was found in one strain of flour beetles, five-fold in a strain of the almond moth, and eight-fold in a strain of Indian-meal moth. The most resistant strains were all from peanut silos where malathion was being used for the third year.
(MQ 1-23)

3. Nonchemical Control. Peanuts stored in high concentrations of CO_2 or N_2 and in normal atmosphere retained relatively constant germination during the first 6 months but lost about 30 percent during the next 3 months. There was further loss by the end of one year but the nuts in CO_2 or N_2 retained a higher rate of germination than did those stored in normal air. Quality tests by the Georgia Agricultural Experiment Stations showed a generally better condition for the nuts stored one year in CO_2 or N_2 than for those in air.
(Exploratory)

Flow-rate studies in small stainless steel towers containing farmers' stock peanuts showed that N_2 gave more uniform purging of O_2 and a slower rate of O_2 diffusion back into the towers than did CO_2 . Observations on insects showed that 80 to 100 percent mortality occurs within 7 days if (1) CO_2 concentration is 70 percent or more, (2) N_2 purging reduces the O_2 content to about 2 percent, or (3) CO_2 purging reduces O_2 to 13 percent and increases CO_2 to 50 percent. Preliminary observations on the changes in atmospheric gas concentrations in sealed containers of infested and noninfested shelled and farmers' stock peanuts indicate that (1) O_2 reaches the lowest level after 3 to 6 weeks, and (2) concentrations of N_2 are higher and CO_2 are lower in shelled than in farmers' stock peanuts.
(Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

- Beasley, E. O. and J. W. Dickens. 1963. Engineering research in peanut curing. N. C. Agr. Expt. Sta. Agricultural Engineering Technical Bulletin No. 155.
- Whitten, M. E. and L. A. Baumann. 1963. Evaluation of a rapid method for determining oil content of soybeans. USDA Technical Bulletin 1296.

Prevention of Insect Infestation

- Harein, P. K. 1963. Marketing: Research on insect control. Peanut Research 1(2):7.
- Redlinger, L. M. 1963. Insect control in stored peanuts. Proceedings, Second National Peanut Research Conference, North Carolina State College, Raleigh, N. C., August 13-15, 1962.

AREA 7

COTTON AND COTTONSEED - MARKET QUALITY

Problem.

Cotton: Technological advancement in production, harvesting, and ginning of cotton brought on by mechanization has resulted in changes in the quality of cotton fiber which are not recognized by present methods of quality evaluation. Mill operators, both domestic and foreign, have reported that these changes have reduced the spinning quality of cotton, thus increasing processing costs and lowering the value of finished products. Precise information is needed on the processing performance and manufactured product quality of cottons which have been subjected to various production, harvesting, and ginning practices in preparation for markets. New and improved techniques, devices, and procedures for measuring quality factors of cotton fiber are needed to provide better grading and standardization of lint cotton, and indicate the true processing performance and manufactured product quality.

Cottonseed: Cottonseed is subject to deterioration in quality and loss in value through fungus damage and contamination, normal metabolic changes, and instability of its oil constituents when exposed to the atmosphere. To maintain its quality, more precise information is needed on the environmental factors which influence these changes during handling, storage, transportation and processing. Also, to insure uniform and standardized products in the marketing channels, new and improved methods for measuring quality factors need to be developed for use in inspection, grading and standardization programs.

USDA PROGRAM

The Department has a continuing program involving textile engineers, cotton technologists, physicists, chemists, and engineers in basic and applied research on objective measurement and evaluation of quality of cotton fiber and on the quality evaluation and quality maintenance of cottonseed. The research is conducted at Washington, D. C., Lubbock, Tex., South Pasadena, Calif., and Clemson, S. C., in cooperation with Clemson University and by research contract with Clemson University, Texas Technological College, Auburn University, and Stanford Research Institute.

The program includes the following foreign projects under P. L. 480: A grant to Centre de Recherches des Industries, Rouen, France, provides for an investigation of fiber maturity and breakage during mechanical processing of cotton, and the relation of these factors to processing performance and product quality. Its duration is 4 years, 1961-1965, and involves P. L. 480 funds of \$64,500 equivalent in French francs.

Another grant to the same institution provides for development of an instrument for homogenizing and orienting fibers in samples for cotton testing. Its duration is 4 years, 1961-1965, and involves P. L. 480 funds with a \$47,000 equivalent in French francs.

A grant to the Fiber Research Institute, T.N.O., Delft, Holland, provides for a study of the influence of length properties on the mill processing performance of cotton. Its duration is 3 years, 1962-1965, and involves P. L. 480 funds with a \$58,000 equivalent in Dutch guilders.

The Federal scientific effort devoted to research in this area totals 20.2 professional man-years subdivided as follows: Cotton 17.7, with 4.7 under research contract; and cottonseed 2.5.

Work terminated during the period included: Development of a small-scale spinning test to determine the spinning efficiency or spinning potential of cotton (MQ 3-1); and an evaluation of spinning and finishing performance of cotton as related to color grade according to the Universal Cotton Standards (MQ 3-13).

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations are engaged in developing breeding stocks and varieties for both upland and long staple types of cotton. The influence of climate, cultural practices and harvesting, and storage conditions on yield and quality of fiber receives much research attention. Mechanical harvesting effects are evaluated by study of fiber properties and through spinning tests. Fiber samples from the breeding and cultural studies are submitted to state and Federal laboratories for testing of fiber and spinning properties. The Tennessee station is giving special attention to devising new and better tests and improving equipment for measuring properties now considered standard in fiber testing. One study is devoted to developing germination tests for cottonseed and measuring seed quality. Another deals with seed cotton moisture content and the effects on cotton fiber quality.

Cottonseed is evaluated for quality and nutritive value--of particular interest is the study of the chemical properties and biological significance of gossypol and gossypol protein complexes. The quality aspect relates to feeding value and quality of the meal for farm animals.

Approximately 12.1 professional man-years are devoted to quality evaluation of cotton and cottonseed.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurements and evaluation of quality of cotton

1. Development of Small-Scale Spinning Tests. The processing of this study has been completed and a report submitted by Auburn University. Small-scale spinning tests developed show that the fiber length measurements are highly related to the spinnable limits value, and are related in general to ends down per 1000 spindle hours, as determined by large-scale spinning tests. The relationship is best when the spinning conditions of the large-scale spinning tests include fine yarns, low twist yarns, and/or high spindle speeds. The results indicate that at least two tests are needed for a reliable spinning performance evaluation; one to measure spinning performance under a normal condition and one at a more extreme condition. A procedure for small-scale spinning tests was developed and recommended. This project has been terminated.

(MQ 3-1(c))

2. Relation of Spinning Performance of Cotton to Color Grade. This research is being done under contract by Texas Technological College. The processing of this study has been completed and the data are being analyzed. Preliminary results indicate that, as the cotton grade decreased from strict middling white to low middling white and from the white to colored grades, the manufacturing waste increased, neps in card web increased, and spinning end breakage increased. The yarn strength did not seem to be related to grade but was related to fiber strength. Upon receipt of the report specified in the contract, the project will be terminated.

(MQ 3-13(c))

3. Evaluation of Interrelationship Between Cotton Fiber Measures. The first and most comprehensive manuscript in an expected series of several from this broad study has been reviewed by the editors of ARS, revised on the basis of their suggestions, and received approval for publication as a Marketing Research Report. This report is entitled "Interrelationship Among Five Cotton-Quality Factors, Including Fiber Strength 1/8-inch Vs. '0' Gauge As Related to Yarn Strength of Three Staple-Length Levels".

A second manuscript is in process of preparation and is entitled "Inter-relationships Among Six Cotton-Quality Measures, Including Fiber Strength at Both The 1/8-Inch And '0' Gauge, As Related to Yarn Strength of Three Staple-Length Levels".

(MQ 3-17)

4. Effect of Various Production, Harvesting and Ginning Practices on Spinning Performance and Cotton Quality. These studies, in cooperation with other agencies, are being conducted by the ARS Cotton Quality Research Station, Clemson, South Carolina. The progress of these studies are as follows:

(a) Mill Performance Vs. Pilot Plant Performance. The processing of this study was completed by the Pilot Plant and by the three cooperative mills. The results indicate that even though the level of spinning end breakage varied among the mills and the Pilot Plant, the trend of end breakage for the spinning lots was very similar for the Pilot Plant and for two of the three mills. The lack of agreement in trends among all mills and the Pilot Plant may be due to the fact that the processing organizations differed. The data are being analyzed and a report will be made.

(b) S.R.I. Drier Vs. Conventional Drier. The processing of this study has been completed. The results indicate that the manufacturing waste was less and the spinning end breakage was lower for cottons dried to 6 percent with the S.R.I. drier than with the conventional drier when the original seed-cotton moisture was 13 percent. These differences between driers decreased as the original seed-cotton moisture decreased. The data are being analyzed and a report is being prepared for publication.

(c) 1962 Defoliation Study. This study was designed to determine the effects of defoliation, desiccation, irrigation management, and field exposure in conjunction with various gin cleaning levels on fiber properties and spinning performance. The processing has been completed. Preliminary analysis of the test results indicate that the differences in fiber and spinning qualities between undefoliated and defoliated or desiccated cottons were very small, although yarn strength was slightly higher and spinning end breakage was slightly lower for undefoliated cotton than for defoliated or desiccated cottons. This study included only early harvested cottons and it will be continued for a second year using both early and late harvested cottons.

(d) 1962 Alcohol Picker Spindle Study. This study was designed to determine the effects of an alcohol moistening agent for the picker spindle on harvesting performance, fiber and yarn quality, and

spinning performance of cotton. The results of this study indicated that the use of alcohol as a wetting agent on the picker spindle had no adverse effects on fiber and yarn properties. However, the spinning end breakage decreased slightly as the use of alcohol increased. The data are being analyzed and a report is being prepared.

(e) Moisture Restoration. This test was designed to study the effects of moisture restoration on the fiber and spinning qualities of cottons. For cotton from Mid-South and West, the results showed that lint ginned from seed cotton which had moisture restored between seed cotton cleaning and the gin stand gave better spinning performance, longer fibers, less short fibers, and a higher break factor than lint ginned from seed cotton dried with no moisture restored. A report is being prepared for this study.

(f) Mechanical Picker Spindle Study (Mississippi & California Cotton). The processing for the third crop year was completed. The results indicate that the trends established by previous studies are holding true for both Mississippi and California cottons; that is, (1) end breakage at spinning was less for hand-harvested cotton than for mechanically-harvested cottons and (2) that the type of picker spindle used in the mechanical harvester affected the level of end breakage. The data are being analyzed and a report is being prepared.

(g) Roller Gin Study. This study was designed to determine the effects of varying pressure on the roller gin flight bar had on fiber qualities and spinning performance when different roll speeds and roll diameters were used in ginning extra-long staple and long staple cottons. The processing was recently completed and the test results are being compiled. Preliminary analyses indicate only small differences in fiber and spinning quality for the Pima cotton. For the Acala 1517 cotton, the mean length, yarn uniformity, and spinning end breakage were adversely affected by increases in pressure on the roller gin. The effects of roll speeds and roll diameters are yet to be determined.

(h) 1963 Foreign Matter Study. This study was designed to determine the effects of foreign matter on spinning performance, production quality and cost of raw cotton. This study has not been processed.

(i) 1963 Bale Compression Study. This study was designed to evaluate the effect of different types of bale compressions on fiber quality and spinnability. This study will be processed under contract by the Texas Technological College.

(MQ 3-33)

5. Spinning Methodology Studies. The second methodology study was designed to study the effects of roving twist, spinning break draft and total draft on product quality and spinning performance. These results showed that, with other frame parameters constant, an increase in the total spinning draft caused only slight adverse changes in yarn strength and yarn uniformity but caused tremendous increases in spinning end breakage. Within the range of break drafts (1.4 to 3.0), a break draft of 1.4 produced the strongest and most uniform yarn but a break draft of about 2.2 produced the lowest level of spinning end breakage. The results of these studies are being used to gain information for the proper interpretations of spinning test results and to serve as a guide in selecting the spinning organizations to be used in the Pilot Plant for cottons of different characteristics. These methodology studies will be continued.

(MQ 3-33)

6. Investigation of Chemical Residues on Surface of Cotton Fibers. Further work was done on the development of test methods and procedures for the detection of chemical residues. Cotton samples from harvesting and ginning studies have been tested for moisture content, ash, pH, carbohydrates, sugars, oil contamination, pesticide and defoliant residues, inorganic elements, and for wax content. When the chemical test results were related to harvesting and ginning treatments, no relationship was found except for wax content. The amount of extractable wax found in samples subjected to high temperatures during ginning was slightly less than found for samples ginned without the use of heat in three of the ginning-spinning studies. However, the level of wax content between studies was greater than the differences due to heat within a study. These investigations will be continued, particularly in regard to the development of test methods and procedures for detecting chemical residues, etc.

(MQ 3-42)

7. Measurement of Frictional Properties of Cotton Fibers. An automatic method for measuring drafting cohesion and drafting-cohesion waves was developed and a manuscript describing the method was cleared for publication. A study of the effects of some fiber properties on roller drafting properties of cotton is in progress. Preliminary tests on several studies have indicated that drafting-force wave amplitude is highly related to fiber length variability.

(MQ 3-43)

8. Instrument Evaluation. The evaluation was continued for the fibro-sampler and Digital Fibrograph combination designed to measure fiber length and length distribution. A progress report entitled "Evaluation of the Fibrosampler and Digital Fibrograph For Measuring Length and Length Distribution of Cotton Fibers" has been prepared. In this evaluation, it was

found that the Fibrosampler, as a sampling device, can be a very rapid and valuable instrument when properly used. The Fibrosampler tends to select long fibers; therefore, careful application is necessary in the type and preparation of sample. The Digital Fibrograph was found to be very stable when simulated samples were tested. Most of the variability in the testing of cotton samples is due to specimen differences. When length measurements by the Fibrograph and array methods are related to processing results, the test methods are about equal in predicting break factor and spinning end breakage. The Digital Fibrograph is currently being used to test samples in all ginning studies.

A Trashmeter was received for evaluation. This instrument was designed to measure very rapidly trash on the surface of cotton samples. Difficulty was encountered in the operation of the first instrument. The laboratory now has an instrument which seems to be stable and preliminary tests have been made. The evaluation of the Trashmeter will be continued, in cooperation with the Cotton Division of AMS.

(MQ 3-47)

9. Relationship of Fiber Maturity to Fiber Breakage During Mechanical Processing. A research project is being carried out in France under a P. L. 480 grant for an investigation of the relationship between fiber maturity and fiber breakage during the mechanical processing of cotton and the relationship of these factors to processing performance and product quality. The results from two bales of Acala 4-42 cotton representing two levels of maturity (Micronaire readings) indicated the following:

- a. The more mature cotton had a longer mean length and a better length uniformity after the ginning process than did the immature cotton.
- b. During textile processing (opening, picking, and carding), a certain amount of fiber is broken; however, a relation between fiber breakage and maturity could not be established.
- c. The mature cotton produced yarns that were stronger, more uniform, and with less neps than did the immature cotton.
- d. Spinning performance was much better for the mature cotton than for the immature cotton.
- e. There does not seem to be any relation between the number of reversals in the fibrillar structure and maturity or length of fibers.

(89-AMS-4(a))

10. Instrument for Homogenizing Test Sample. Under a P. L. 480 grant, a research project is being carried out in France to develop an instrument for homogenizing and orienting cotton fiber in a sample for fiber testing. Several approaches to this problem have been studied but without success. Pneumatical and electrostatical means, separately and in combination, have failed in the separation of cotton fibers. One instrument developed using mechanical means (nylon brushes and rolls with metal clothing) did an excellent job in opening and separating the fibers but fiber damage due to breakage was too great to solve the problem of fiber breakage, two instruments are being developed and tested which will handle the fibers more gently. One instrument involves mechanical means only and the other a combination of mechanical and pneumatical.

(E9-AMS-5(a))

11. Influence of Fiber Length Distribution On Mill Processing. A research project is being carried out in Delft, Holland, under a P. L. 480 grant to study the influence of fiber length distribution on mill processing of cotton. The large-scale spinning for both the Acala and Deltapine cottons have been completed. The results show that the number of end breakage for the Acala variants were lower than for the Deltapine cotton. The trends obtained from the variants were the same for both varieties. The variant of the comber noil mix resulted in a significantly lower end breakage than for the variant of the cut fiber mix even though the fiber length distributions for the two mixes were practically identical and no essential differences in yarn properties were noted.

(E19-AMS-8(a))

B. Objective measurement of quality of cottonseed

1. Method for the Rapid Measurement of the Refining Loss of Cottonseed Oil in Small Lots of Seed. A study of refining losses of crude cottonseed oil and their possible correlation with conductivity measurements were carried out at several vegetable oil refineries. The results indicate that it is difficult to estimate refining losses with a single conversion factor. This is due to the difference in conductance of the three major compounds lost in the refining process - gossypol, free fatty acids, and phosphatides. The conductance of ammonium salts of gossypol are almost double those of free fatty acids salts and nearly 20 times that of the ammonium phosphatides.

To better understand refining losses in vegetable oils we are presently studying the simpler crude oil of soybeans. This oil does not contain gossypol and its major refining losses should therefore be mainly due to the free fatty acids and phosphatide content. Our studies have shown that more than 90% of the refining loss of soybean oil is due to its phosphatide content. The phosphatide range was found to be 0.5 to 5.0% with the majority of the samples falling between 2 and 3%. Free fatty acids content on the

other hand was found to be more constant, about 0.2% and with a smaller range of 0.2 to 0.4%. A possible conclusion from these observations is that it might be possible to estimate refining losses of soybean oil by determination of the phosphatide content rather than by a neutral oil determination with the phosphatide analysis being simpler and faster to perform than a neutral oil determination.

(MQ 3-45)

2. Re-evaluation and Improvement of Official Cottonseed Standards for Reflecting More Accurately the Value of Products Obtained from Cottonseed. The accuracy of the cottonseed grading system is dependent upon the accuracy of sampling procedures and methods of analysis of cottonseed and its products as well as their price relationships. During the past season a pneumatic method of sampling cottonseed was field tested (in cooperation with the Cotton Division, Agricultural Marketing Service and commercial interests) at two locations. This sampler is more rapid, less hazardous to operate and more accurate than the old official "corkscrew" type. It has been approved for use in the USDA Official Methods for Sampling, Analyzing and Grading Cottonseed, also approved by the National Cottonseed Products Association, and the American Oil Chemists Society. The new sampler will be in operation at plants of approximately one-third of all U. S. processors of cottonseed during the coming season.

A rapid method for determining oil in meal and cake was developed using the equipment employed in the rapid oil-in-seed assay. A modification of this method may also be used to determine oil in soybean meal. This rapid method will allow the processor to control his product more uniformly.

A study was made of price relationships of cottonseed and its products to oil-meal factors which will more accurately reflect the true value of the seed at different product price levels.

(MQ 3-51)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurements and Evaluation of Quality

Doughtie, R. T. Jr., and M. E. Whitten. 1964. A new cottonseed sampler. Agricultural Marketing. July.

(MQ 3-5)

Newton, Franklin E. and Samuel T. Burley, Jr. 1964. Fresh look at break drafts. Paper presented at Cotton Marketing Conference-Research Clinic, Pinehurst, N. C., February 1964 and published in Textile World, pp. 43-47. March.

(MQ 3-33)

- Newton, Franklin E. and Samuel T. Burley, Jr. 1964. Spinning performance as influenced by fiber properties, yarn properties, and spinning frame parameters. Paper presented at ATMI Open House, Clemson, S. C., April 1964, at the Alabama Textile Operating Executives Meeting, Auburn, Alabama, July 23, 1964, and published in Textile Bulletin, pp. 40-44, June. (MQ 3-33)
- Ross, John E. and Edward H. Shanklin. 1964. Effect of gin drying and cleaning of cotton on fiber length distribution and yarn quality. MRR-666-ERS-AMS-USDA July. (MQ 3-33)
- Newton, Franklin E., E. W. S. Calkins, and A. C. Griffin. 1964. Fiber and spinning properties of cotton as affected by certain harvesting and ginning practices. MRR-656-AMS-ERS-ARS-USDA June. (MQ 3-33)
- Shanklin, Edward H. and Robert A. Mullikin. 1964. Effect of cotton ginning practices on cotton yarn properties, weaving performance and fabric properties. MRR-655-AMS-USDA May. (MQ 3-33)
- Mullikin, Robert A. and Frances Carpenter. 1964. How combed yarn mills can use span length measurements. Paper presented at the Textile Quality Control Association Meeting, Clemson, S. C., September. (MQ 3-47)
- Whitten, M. E. and L. A. Baumann. 1963. Evaluation of a rapid method for determining oil content of cottonseed. USDA Tech. Bul. 1298. (MQ 3-5)

AREA 8

WOOL AND MOHAIR - MARKET QUALITY

Problem. Animal fibers in raw or manufactured form are subject to damage by several kinds of fabric insects, estimated to cause at least \$350 million loss annually. Basic research on the physiology and chemistry of wool digestion by insects is needed to provide information that can be used in developing better preventive treatments. The safety of several compounds now used is being questioned, and safer effective treatments are needed. Urgency is attached to this need by the concern about pesticide residues in clothing expressed by the President's Science Advisory Committee in its 1963 report on pesticide use.

USDA PROGRAM

The Department has a continuing program at Savannah, Georgia, involving entomologists and chemists engaged in applied research on the protection of wool and other animal fibers against insect damage. The research is conducted in cooperation with the Armed Forces Pest Control Board and various industry groups.

A grant to the Shri Ram Institute for Industrial Research, Delhi, India, provides for studies on the "canary coloration" of raw wools. Its duration is for 5 years, 1963-1968, and involves PL 480 funds with a \$98,454 equivalent in rupees.

The Federal scientific effort devoted to research on prevention of insect infestation totals 1.5 professional man-years. In addition, some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in wool.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research related to the market quality of wool and mohair is in progress at the Kentucky, Montana, New Mexico, Texas, and Wyoming stations.

The Kentucky program is directed to determining the grade distribution of wool sold in Kentucky and analyzing the grade-price relationships in the various areas of the State. Similar work is involved in programs at the other stations. Montana researchers, for example, seek to determine the relationship of color of scoured wool and colored fiber content of grease

wool to their combing performance and market value. Other research deals with the effect of fiber measurement on the price of wools. Research directed to measuring the effect of outdoor weathering on wool fabrics made from fibers with selected properties is also in progress. One Texas study seeks to determine present domestic and foreign attitudes toward utilization of mohair blended yarns and fabrics and relate these to market qualities.

Total research effort on wool and mohair quality is 3.4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. "Canary Yellow" Coloration of Raw Wool. The first progress report has been received and covers the partial collection of analytical data obtained on samples of both yellowing and nonyellowing types of fleeces. The data have not been completely analyzed but cover information on: pH of suint, suint content, grease content, cystine, lanthionine, total and free sulfur content, diameter, medullation, thickness of grease layer, strength and elongation, specialized mechanico-chemical analysis, super contraction, plasticity, set, differential thermal analysis and degree of yellowness. The completed analyses will lay the foundation for undertaking the other phases of the proposed plan of research. (A7-AMS-12(a))

B. Prevention of insect infestation

1. Insecticide Evaluation. Laboratory tests with 54 new compounds failed to reveal any outstanding candidates for further testing. Barthrin and dimethrin appear promising for further evaluation as mothproofing agents on the basis of performance in preliminary tests and because of their extremely low mammalian toxicity as reported thus far. Followup studies on promising surfactants mentioned last year gave results justifying further developmental work. Quaternary ammonium compounds applied to washable woolens in the last rinse water indicated that satisfactory mothproofing properties might be obtained by a home treatment with such materials. The manner in which the rinse water was extracted seemed to have no influence on the effectiveness of the treatment. Better results were obtained in automatic washers than in hand washers. A heat-sealed kraft-polyethylene envelope used by the Armed Forces for stored woolens, and the new Quartermaster clothing container with overtape on all seams, were excellent physical barriers to the entry of fabric pests. (MQ 1-26)

AREA 9

POTATOES - MARKET QUALITY

Problem. The problem arising from the numerous potato varieties, areas of production, seasons of harvest and special storage and handling requirements for specific uses require a continuing program of research on handling, storage, transportation, physiology, wastage control and quality measurement. The increased demand for potatoes to be used for chips, frozen french fries and other processed forms has created special problems to prevent undesirable chemical changes due to low temperatures during storage and transport. The use of higher temperatures has brought on additional problems of moisture loss and of bacterial and fungal decay. Higher temperature storage also calls for control of sprouting, with increased emphasis on chemical sprout inhibitors. Objective indices are needed to identify quality factors that are important for specific product usage and relate measurable characters of the raw product to quality of the processed product. Also needed are instruments for non-destructive detection and rejection of potatoes with internal disorders during grading.

USDA PROGRAM

The Department has a long-term program involving horticulturists, plant pathologists and plant physiologists engaged in applied and basic research. The work at East Grand Forks, Minnesota, is conducted in cooperation with the Minnesota and North Dakota Agricultural Experiment Stations and the Red River Valley Potato Growers Association. The work at Presque Isle, Maine, is in cooperation with the Maine Agricultural Experiment Station. Research on transportation of early potatoes for chips is conducted by the Fresno, California, station. The studies at Beltsville involve specialized storage problems and basic research. Studies on market diseases are conducted at Chicago and Belle Mead, New Jersey.

The Federal scientific effort devoted to research in this area totals 6.0 professional man years. Of this number 1.0 is devoted to objective measurement of quality, 0.5 to handling and packaging, 1.5 to storage, 0.5 to quality maintenance during transportation, 0.5 to postharvest physiology, 1.5 to postharvest disease control, and 0.5 to program leadership.

Work terminated included projects on the effect of ventilation on quality (MQ 2-35); prestorage treatments on potato diseases (MQ 2-39); and market quality of southeastern potatoes (MQ 2-50). Some of the work formerly conducted under MQ 2-35 and MQ 2-39 is being conducted under new line projects (MQ 2-90 and MQ 2-92).

CURRENT PROGRAM OF STATE EXPERIMENT STATIONS

Market quality research of potatoes at the State stations concerns potato storage; evaluation of the effect of varieties, and of cultural, handling, and storage techniques on processing quality; and control of disease in storage and in the marketing channels. Storage research involves studies of sprout controlling chemicals and methods of application, optimum storage temperatures and humidities, forced air ventilation and air movement, and the response of varieties to storage conditions.

Studies related to processing quality include evaluation of breeding lines and new varieties for processing quality. Research is in progress on the causes and remedies for after harvest darkening of potatoes. Physical and chemical properties of potato tissue in relation to sloughing are being investigated. Other research involves the relation of processing technique and chemical composition to the quality of potato chips, and the effect of extended storage on potato texture. Methods are being devised for storing whole unpeeled and peeled potatoes and sliced potatoes in various gases and at different temperatures to maintain reducing sugars at a low level.

Disease investigations include studies of potato scab, bacterial ring rot, other bacterial and fungal diseases, identification and control of potato virus diseases and determination of the effect of such diseases on yield and market quality, and biochemical and other studies for the control of nematode diseases of the potato.

Total market quality research effort on potatoes at the State stations is approximately 6.7 professional man-years. There are 25 projects in 13 States contributing in whole or in part to this research.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Predetermining Processed Quality in Potatoes. Work on relating characteristics of the fresh product to frozen french fry quality is just getting under way at Beltsville in cooperation with EURD. (MQ 3-56)

B. Quality maintenance in handling and packaging

1. Mechanical Injury Incident to Sizing Potatoes into Storage. Increases in bruising of Pontiac and Norland potatoes during sizing into storage at East Grand Forks were minor with Size A tubers, but were of some concern with large jumbo sized tubers. (MQ 2-78)

2. Stone Separation. Two varieties of whole seed subjected to a simulated water flume-stone trap operation and then shipped from Maine to West Virginia reacted no differently when planted in the field than comparable potatoes handled dry. (MQ 2-93)

C. Quality maintenance in storage

1. Storage Temperature on Processing Quality. Evaluation of the effects of storage temperatures on the flake quality of Red River Valley potatoes was continued. Specific gravity, production of flakes per minute and the percent yield of dried flakes were not affected by the storage temperatures used (40°, 45°, and 55° F.). Potatoes stored at 40 and 45° F. were reconditioned before processing. Acceptable flakes were made of all four varieties tested during storage from January until the end of July. (MQ 2-69)

2. Methods and Rates of Ventilation on Quality of Maine Potatoes. Almost complete control of storage rot was obtained in both 38° F. (bin) and 45° F. (bin and pallet box) storages with through ventilation rates of 1 to 4 cfm per barrel. Weight losses in 45° F. bin storage ranged from 9.5% in bins with no forced air circulation to 12.5-14.0% in bins with forced-air circulation. Weight losses in pallet boxes average 6.5%. In 38° F. bin storage the weight losses ranged from 6% in the bins with no forced air circulation to 8-10% for the bins with forced air circulation. In general, weight losses increased as the airflow rates increased. The amount of injury due to pressure in the 45° F. bin storage increased as the airflow rates were increased. Internal black spot increased as the percent of severe pressure spot increased. (MQ 2-92)

3. Control of Sprouting of Potatoes. After 5 months at 60° F. and high humidity Isopropyl N-(3-chlorophenyl) carbamate (CIPC) dipped potato tubers had no external nor internal sprouts. Untreated tubers stored in same chamber with CIPC dipped tubers in laboratory storages at Beltsville developed 10 percent internal sprouting and 196 grams of external sprouts per 100 tubers. Untreated tubers in potato cellar storages in which no sprout inhibitor was used, had 0.1 percent internal sprouting and 1224 grams per 100 tubers of external sprouts. Apparently, under some conditions, low levels of CIPC may stimulate internal sprouting but if the concentration is high enough to control external sprouting, internal sprouting is also controlled.

In tests in Maine, there was no detectable difference in residues of CIPC when applied with a "Swingfog" applicator using nozzle opening diameters of 0.8, 1.1, and 1.4 mm.

A new sprout inhibitor, 2,6-dichlorobenzonitrile, (Casoron) was tested at Beltsville. When applied at concentrations of 1, 10 and 20 ppm to potatoes going into storage it did not control sprouting. The same quantity of chemical vaporized in the atmosphere surrounding the potatoes caused severe necrosis in the tubers. (MQ 2-31)

D. Quality maintenance during transportation

1. Transit Temperatures of California Potatoes. An early-season shipment (May 28) of Kennebec potatoes from Kern County, California to the mid-west using the conventional protective service, Standard Ventilation without ice, resulted in an average transit temperature of 51° F. and dark, unattractive chips. Another shipment made on June 2 averaged 60° in transit and produced desirably light colored chips. Early-season Kennebecs grown under cool weather conditions appear to withstand relatively low transit temperatures (55° F.) for the time normally required for shipment to the mid-west. However, actual transit temperatures early in the season sometimes fall below the safe level. The results of this work are being prepared for publication. (MQ 2-55)

2. Heavy Loads of Maine Potatoes. Preliminary tests conducted with 50-pound paper bags shipped to Boston indicated that there is an increased danger of grade damage occurring to potatoes shipped in very heavy loads, particularly if care is not taken during loading and unloading. This increase in damage could offset savings in freight charges if the damaged potatoes were removed in repacking operations. (MQ 2-42)

E. Postharvest disease control

1. Pre-storage Washing. Neither a hot-water dip nor a surface active agent applied at harvest or 1 month after harvest controlled lenticel infection of Maine potatoes. In general, there was more lenticel infection when potatoes were washed at harvest than when washed 1 month after harvest. (MQ 2-93)

2. Hot Water Treatment of Seed Potatoes. Whole seed (B-size) of three varieties were not adversely affected during transit, or in pre-planting storage when treated for 3 minutes at 130° F. and shipped to West Virginia. Emergence date, stand, disease development in the field or weight of sprouts were also not influenced by the hot water treatment. (MQ 2-90)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement of Quality

Findlen, H. 1964. Effect of Maturity on the Chipping Quality of Irish Cobbler and Kennebec Potatoes. USDA, Marketing Research Report 644. (BS 2-23)

Findlen, H., and Glaves, A. H. 1964. Vine Killing in Relation to Maturity of Red River Valley Potatoes. USDA, Tech. Bul. 1306. (BS 2-23)

Quality Maintenance in Handling and Packaging

Hardenburg, R. E. 1964. Greening of Potatoes During Marketing--A Review. Amer. Potato Jour. 41(7):215-220. (MQ 2)

Quality Maintenance in Storage

Heinze, P. H. 1964. Factors Affecting Quality of Early-Crop Potatoes for Chipping. Proc. Production and Technical Div. of Potato Chip Inst. Int. 1964:11-12. (MQ 2)

Findlen, H. 1964. Recent Developments in Handling, Transportation, and Storage of Potatoes in the Red River Valley. Ohio Veg. and Potato Growers Assoc. Proc. 1964:91-95. (MQ 2)

Heinze, P. H., Sparks, W. C., Hunter, J. H. and Redit, W. H. 1964. Storage and Transportation of Potatoes. Potato Hdbk. 9:30-34. (MQ 2-42)

Postharvest Physiology

Craft, C. C. 1963. Respiration of Potatoes as Influenced by Previous Storage Temperatures. Am. Potato Jour. 40: 289-298. (Pioneering Research)

AREA 10

POULTRY PRODUCTS - MARKET QUALITY

Problem.

Technological developments continue in the poultry industries and create many new problems relating to the market quality of poultry and egg products. Introduction of highly mechanized equipment and machinery plus new techniques in processing affect the absorption and retention of moisture of ready-to-cook poultry, the contamination of poultry and egg products by spoilage microorganisms, the physical damage to poultry carcasses, and the sanitary and functional properties of egg products. To maintain quality of these products in marketing channels, more information is needed regarding the effects of the new technology as well as changes that occur during transportation and storage. In addition, objective methods of quality evaluation are needed for use in developing improved criteria and standards for inspection and grading to insure uniform, standardized, and wholesome products.

USDA PROGRAM

The Department has a continuing program involving food technologists and bacteriologists engaged in basic and applied research in the quality evaluation and quality maintenance of poultry products. The research is conducted at Beltsville, Maryland, and at Athens, Georgia, in cooperation with the Georgia Experiment Station and through a research contract with the University of California, Davis, California.

The Federal scientific effort devoted to research in this area totals 6.0 professional man-years, about equally divided between objective measurement and evaluation of quality, and handling, packaging and storage.

Studies on the maintenance of quality during the off-farm handling, killing, dressing, eviscerating, cutting-up, chilling and packing of fresh poultry in the southeastern states (MQ 2-41) were terminated during this period.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

State stations maintain a continuing basic and applied research program on the market quality of poultry products. The regional effort in this area is conducted under NCM-7, Improving Market Quality and Utilization of Poultry Products. Personnel from eleven states and the United States

Department of Agriculture are cooperating on this regional project. Research emphasis is about equally divided between problems on eggs and on poultry meats.

With broilers, considerable effort is devoted to investigation of processing and storage conditions and their influence upon the shelf-life of raw poultry. Additional study is given factors which affect the quality of fresh, frozen and processed poultry meat in market channels. The quality, stability and acceptability of processed and pre-cooked poultry meat products is also studied with a view to development of more effective means for preserving quality. Other investigations seek to evaluate the effect of production practices on the composition and market quality of poultry meat.

Egg quality research is concerned with determination, evaluation and improvement of methods of controlling deterioration of shell eggs in market channels. Investigation of the effects of various treatments on the quality, nutritive value, stability and public health aspects of shell eggs and egg products involves study of: seasonal variation of egg quality; egg washing techniques; the biochemical changes which occur during marketing and storage; and certain causes of egg yolk discoloration which may relate to feeds used. The physical and chemical properties of egg shells are studied and attempts made to relate these shell properties to retention of the interior quality of the egg. Other research related to maintaining market quality involves design, construction and testing of experimental egg cleaners. Consumer studies attempt to relate consumer acceptance with egg grades and levels of interior quality.

The total research effort devoted to market quality research in poultry products is 20.4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Quality measurement and evaluation of quality

1. Effect of Various Disease Syndromes on Wholesomeness of Market Poultry.

The primary emphasis in this study has been an attempt to artificially produce the severe type of air sacculitis most commonly encountered during official inspection in commercial poultry processing plants. This condition was not produced when the different groups of chicken fryers were inoculated with (a) Mycoplasma gallisepticum (S₆-PPLO) followed one week later with Escherichia coli or (b) with Pasturella multocida followed one week later by Infectious Bronchitis virus (IBV). The inoculation of fryers with (c) a Fowl pox vaccine followed three days later with M. gallisepticum intratracheally was also ineffective in producing air sacculitis.

Severe air sacculitis did develop when the following combinations of agents were used to inoculate chicken fryers: (1) a synovitis strain of PPLO when injected via the foot pad route; (2) Hemophilus gallinarum and the Roakin strain of Newcastle Disease Virus (NDV); (3) M. gallisepticum IBV, and E. coli (inoculations one week apart in that order); and (4) M. gallisepticum, IBV, and H. gallinarum (inoculations one week apart in that order). In the latter three trials, there was a tendency for lesions to resolve if birds were held long enough before slaughter. Thus, condemnation rates were higher for birds infected in the latter part of their growing period than for birds infected at an early age. Medication with antibiotics appeared to be of significant benefit only in the trial involving infection with M. gallisepticum, IBV, and H. gallinarum.

Artificially induced infections of turkeys of various age groups with M. gallisepticum (S₆-PPLO) affected younger birds most severely but at the market age of twenty weeks, condemnation rates of these birds were quite low indicating that they may overcome the infection prior to slaughter. A study of the action of the NTF strain of Mycoplasma in turkeys indicated that this agent was highly infectious. Turkeys infected at an early age suffered a much higher mortality rate than older groups after inoculation. At post mortem, birds that were in an active stage of the disease had such severe lesions that almost 100% were condemned.

The pathogenic action of Erysipelothrix insidiosa indicated that this agent was highly virulent, for both sixteen- and twenty-week old turkeys. Vaccinated birds were somewhat more resistant than non-vaccinated but did show appreciable mortality, particularly where they did not receive penicillin treatment. At termination, none of the remaining infected birds were condemned for unwholesomeness. Such carrier states were found twice as frequently in nontreated as in treated birds.

(MQ 3-22(c))

2. Assessing the Sanitary Quality of Egg Products. A comparison study of total viable aerobes, enterococci and coliforms in commercial egg products was completed. Under in-plant conditions, bacteriological examinations were made of liquid and dried egg products. In all liquid samples examined, coliforms were present in greater numbers than the enterococci. Significant correlations between the numbers of both enteric groups and the numbers of total viable aerobes were found in liquid whole egg but not in liquid yolk, whereas a significant relationship existed between the number of coliforms and the number of enterococci in all liquid products. All counts were found to be lower in liquid yolk than in liquid whole egg. This was thought to be due to the restricted contact of individual yolks with contaminated machine surfaces during the separation process. The total count of the yolk therefore did not appear to be a good index of sanitary practices.

Tests involving spray-dried whole egg and yolk products showed only minor changes in numbers of enterococci before and after drying whereas total viable aerobe and coliform counts were reduced. Subsequent storage of these products at 5° C for 8 months resulted in further decreases in coliforms and total aerobes and only a slight decrease in enterococci. Heat treatment of pan-dried egg white (130° F - 8 days) reduced all three counts to non-detectable levels. This project will be terminated.

(MQ 3-31)

3. Determination of Lighting for Proper Grading and Inspection of Poultry. Preliminary surveys to determine typical lighting conditions in processing plants have been made. "Daylight" type lighting equipment has been obtained. Installation and evaluation of lighting equipment is planned.

(MQ 3-52)

4. Methods to Evaluate Shelf-life of Eviscerated Poultry. Accuracy of Bacterial Sampling of Chickens. Bacterial counts of eviscerated chickens were determined in a commercial poultry processing plant to assess the variation in total aerobic bacteria among birds of the same lot and the variation among different areas of the same bird. Analysis of these data has been completed but evaluation and interpretation of the results are still in progress.

(Exploratory work -
Project Pending)

B. Quality maintenance in handling, packaging, and storage.

1. Chilling of Eviscerated Broilers. A comparison of three methods of chilling eviscerated broilers, i.e., (1) in still air at 40° F; (2) in an agitated ice plus water mixture; (3) or in agitated chilled water, was made. Ice plus water chilling caused a significant percentage reduction of bacteria per cm² of skin as compared to the chilled water process. Chilling in 40° F air caused significant increases in bacterial counts. Both wet chilling methods resulted in increases in carcass weight whereas air chilling resulted in slight weight loss. No organoleptic differences were detected in either broth or meat from carcasses chilled by the three methods.

(MQ 2-41)

2. Bruising of Broilers. A study on factors affecting bruising of broilers indicated that the manner of loading live birds into coops on trucks has a significant effect on the incidence of bruising of broilers after slaughtering. A significantly lower percentage of birds with bruises or discolorations was found in the middle layer of coops than either the top (ninth) or bottom layer. Aluminum coops and coops whose openings were padded with foam rubber, also reduced the number of bruised birds.

(MQ 2-41)

3. Quality Retention of Eviscerated Poultry as Related to Method of Slaughter. The rate of blood loss and amount of blood retained by cut-up chickens was determined when birds were slaughtered, using the following methods: (1) electric stun and outside cut; (2) brain stick and outside cut; (3) skull puncture and outside cut; (4) carbon dioxide immobilization and outside cut; (5) Kosher cut; and (6) outside cut. Blood loss was determined at 30 seconds, 90 seconds, 3 minutes, and 3-5 minutes after slaughter. The blood remaining in the cut-up parts was determined by assaying the radioactivity of the part resulting from ante-mortem injection of radioactive iodinated serum albumin (I^{131}). The parts assayed were breast, wings, thighs, drumsticks, kidneys and Bursa of Fabricius, back, neck, liver, heart, gizzard, head, feet, spleen, and offal. The data are presently being analysed.
(MQ 2-81)

4. Changes in Eggs During Cold Storage. Determinations were made of inorganic phosphorus, reactive NH_2 , and glucosamine in eggs stored up to nine months. No important differences were found. It was determined that the thinning of egg white was not related to splitting of a hyaluronic acid-protein complex.
(E25-AMS-5(a))

5. Oxidative Deterioration of Cooked Poultry. A mixture of polyphosphates has been found to be effective in delaying oxidative deterioration in commercially processed and cooked fryer chickens. After storage of one week at 40° F, phosphate-treated chicken meat showed no, or very slight, off-odor and a thiobarbituric acid (TBA) value of about 1, whereas untreated control chickens had a slightly to moderately strong off-odor and a TBA value of about 6.

(Exploratory Work -- Project Pending)

6. Radiation Pasteurization of Eviscerated Poultry. Fresh and frozen tray-packed cut-up fryer chickens were irradiated with a cobalt-60 source with 0.0, 0.1, 0.3, and 0.5 Mrads. Irradiation at the three levels conferred additional days of shelf-life on both fresh and frozen birds when they were subsequently stored at 34° F and at 40° F. There appeared to be no significant difference in shelf-life between fresh birds receiving the three levels, nor between those stored at 34° or 40° F. A shelf-life of 23 to 25 days was found at all three levels as compared to 11 days for the unirradiated controls. Shelf-life extension of birds irradiated in the frozen condition was not as great (4 to 5 days extension) at the 0.1 Mrad level as it was at the two higher levels. Data from panel evaluations for off-odor in both the raw and cooked chickens are being analyzed. A study of the development of oxidative deterioration in chickens which had been irradiated in the frozen

condition at 0.1 and 0.5 Mrad level and subsequently stored at 40° F up to 27 days and at -15° F up to 14 weeks was also carried out employing panel evaluations for off-odor and the TBA test. Cooked samples of the irradiated frozen chicken stored at 40° F were also tested. Analyses of these data are in progress.

(Exploratory Work)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Quality Measurement and Evaluation of Quality

Tarver, F. R., Jr., and K. N. May. 1963. Effect of slaughter technique, immersion scald, and refrigerated storage on bacterial counts of poultry air sacs. Poultry Sci. 42:1141-1145.

(MQ 3-22(c))

Tarver, F. R., Jr., and K. N. May. 1963. Kinds of aerobic bacteria in air sacs of processed poultry. Poultry Sci. 42:1459-1460.

(MQ 3-22(c))

Quality Maintenance in Handling and Packaging

Cox, C. J. and K. N. May. 1964. Factors affecting bruising of commercial broilers. Ga. Agr. Expt. Sta. Technical Bulletin NS 35.

(MQ 2-41)

Kotula, A. W. and J. A. Kinner. 1964. Airborne microorganisms in broiler processing plants. Applied Microbiology 12(3):179-184.

(MQ 2-10)

Kotula, A. W. and A. J. Mercuri. 1964. Food preservation by gamma irradiation - a review. The Maryland Poultryman, July, pp. 1-5.

(Exploratory work -
project pending)

May, K. N. 1964. What happened to the "boom" in frozen poultry. Broiler Business, June. p. 16

(MQ 2-41)

May, K. N. and R. L. Saffle. 1964. Quality of ice-packed and frozen chicken. 2. Taste panel evaluations. Poultry Science, 43(4): 1044-51.

(MQ 2-41)

Rogers, P. D. and K. N. May. 1963. Cooling of eviscerated broilers in chilled water. Ga. Agr. Expt. Sta. Technical Bulletin 34.

(MQ 2-41)

Walters, R. E. and K. N. May. 1963. Thermal conductivity and density of chicken breast muscle and skin. Food Technol. 17:130-133.

(MQ 2-41)

Winawer, H. H. and K. N. May. 1964. Quality of ice-packed and frozen chicken. 1. A consumer preference study. Poultry Sci. 43(4):1031-1035.

(MQ 2-41)

Stokes, D. E., A. W. Kotula, A. J. Mercuri, and F. K. Buxton. 1964. Evaluation of specified shrink films for prepackaging frozen cut-up chickens at processing plant. USDA, AMS, Marketing Research Report No. 662, 15 pp.

(Exploratory Work -
project pending)

AREA 11

TOBACCO - MARKET QUALITY

Problem. Stored tobacco and tobacco products are subject to insect damage that seriously affects the grade, value, and potential end use. The price support program has resulted in a large buildup of stocks, some held for as long as 7 years, about twice the normal period for storage and aging. The long-term storage and the compact, dense structure of the tobacco as stored in hogsheads make insect control difficult. Repeated, heavy applications of fumigants or other control measures during extended storage has raised a question as to the extent and significance of residues that may be accumulated. Treatments applied during storage should be assessed further to be sure they are safe. Measures now used only hold insect populations in check and do little to reduce them or prevent them from becoming established. Attention should be given to the development of measures that will minimize or eliminate the use of chemicals, and at the same time effectively eliminate or prevent infestations. To accomplish this it will be necessary to develop much more basic information than is now available on the ecology, physiology, and behavior of the insects that attack stored tobacco.

USDA PROGRAM

The Department has a continuing program at Richmond, Virginia, involving entomologists engaged in basic and applied research on the insect problems of stored tobacco and tobacco products in the marketing channels. The research is conducted in cooperation with farmers' cooperative associations, industry groups, and the Agricultural Stabilization and Conservation Service of this Department.

The Federal scientific effort devoted to research on prevention of insect infestation totals 3.3 professional man-years. In addition, some of the cross-commodity research at Savannah, Georgia, reported in Area 13, "Insect Control in Marketing Channels," is also applicable to the insect problems in stored tobacco.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Scientists of the State agricultural experiment stations are engaged in basic and applied research related to tobacco quality. Much attention is given to smoking quality, determination of varieties, and tobacco subjected to a wide range of management practices. Other basic studies

concern objective methods for determining smoking quality, the chemistry of curing, and fermentation processes to provide specific types of tobacco leaf, and the measurement of physical properties.

Use of machines and machine methods in tobacco harvesting and handling is expanding. Research is directed to determining the effects of mechanization procedures on quality. Work directed to devising new methods for the measurement of the chemical and physical properties of tobacco is of direct interest. These methods are applied in determining quality characteristics. The Puerto Rico station has a study on tobacco quality which is aimed at determining standards of quality in tobacco and correlating these with preferences of cigar smokers.

The total program involves 11.9 professional man-years for quality related research on tobacco.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Prevention of insect infestation

1. Basic Biology and Ecology. Tobacco moth larvae failed to mature at relative humidities of 30 and 40 percent when temperatures were 70 or 80° F. Some larvae lived for 5½ months before death, and were only half the size of normal larvae, which develop to adults in about 1 month. At relative humidities of 50 and 60 percent some larvae survived and matured to adults but their developmental period was 3 to 4 times longer than normal, and shorter at 80° than at 70° F. (MQ 1-7)

2. Insecticide Evaluation. Flue-cured tobacco at 14-percent moisture content accumulated more inorganic bromide residue during methyl bromide fumigation than did tobacco containing 10 percent moisture. The residue became progressively greater during 12 consecutive fumigations, and a 4-fold increase in dosage produced 3 to 4 times more residue. The tobacco did not develop any abnormal taste until after 10 fumigations at the rate of 16 ounces of methyl bromide per 1,000 cubic feet. When the rate was increased to the excessively high amount of 64 ounces, abnormal flavor was present after only 2 fumigations. (MQ 1-33)

A pulsating insect retention cage was designed and constructed to hold crawling and flying insects, especially the adult cigarette beetle, on a non-vibrating test surface without harming or adversely influencing the reactions of the test insects. Using this equipment it is now possible for the first time to conduct satisfactory residual toxicity and repellency tests with the cigarette beetle and such studies are now in progress. (MQ 1-35)

3. Insecticidal Control. Insecticide-coated kraft paper bands were placed around the middle of hogsheds of tobacco that were broken open

yearly for inspection. After 3 years of storage all hogsheads with bands coated with synergized pyrethrum were protected against insect damage in the "break;" 75 percent of the hogsheads with TDE or lindane on the bands were protected; and 25 percent of the hogsheads had no appreciable damage when there were no bands, untreated bands, or a combination of methoxychlor and synergized pyrethrum on the bands. (Exploratory)

4. Nonchemical Control. A small vacuum-steam chamber was designed and constructed to permit laboratory studies in which tobacco could be treated under better controlled conditions than with commercial equipment. Variable factors evaluated were temperature, amount of vacuum, and rate of steam flow. Mortality of all stages of the cigarette beetle was obtained in 25 minutes at 120° F. and in 1 minute at 140° F. There is indication that the treatment at sublethal levels adversely affects the reproductive capability of surviving adult beetles. (Exploratory)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Prevention of Insect Infestation.

Childs, Dana P. 1964. The effects of flowing steam in vacuum against the cigarette beetle. Abstract in Proceedings, Tobacco Research Workers' Conference, Columbus, Ohio, January 27-30, 1964.

Childs, Dana P. 1964. New pulsating cage tames lively insects. *Agricultural Marketing* 9(8): 3-4, August 1964.

Tenhet, Joseph N. 1964. Repellents for the cigarette beetle. Abstract in Proceedings, Tobacco Research Workers' Conference, Columbus, Ohio, January 27-30, 1964.

AREA 11 b

CUT FLOWERS AND ORNAMENTALS - MARKET QUALITY

Problem. The rapid increase in production of field-grown narcissus, gladiolus, lilies, stocks, and chrysanthemums into a multimillion dollar business in Florida, California, and other states has raised many problems in marketing. Information on methods and materials for use in packaging, on the temperature requirements and atmosphere modifications for storage and transit, and on the control of decay are among the most urgent problems.

USDA AND COOPERATIVE PROGRAM

The Department has a very limited program in market quality research on cut flowers and ornamentals, amounting to approximately 1.0 professional man-year. This research is conducted at the Fresno and Beltsville laboratories. The work on quality maintenance during transportation is conducted in cooperation with the California Floral Traffic Conference.

PROGRAM OF STATE EXPERIMENT STATIONS

Research on market quality of cut flowers at the State stations involves three distinct areas: determination of grades and standards for cut flowers, studies of the keeping quality of cut flowers under different methods of holding, and disease investigations. Studies of grades and standards for cut flowers have been coordinated into a regional project NCM-35, Market Grades and Standards for Specified Cut Flower and Potted Plant Crops. Crops included for study in this project are Easter lilies, poinsettias, snapdragons, roses, and chrysanthemums.

Studies of keeping quality include consideration of such factors as chemical preservatives; growth regulators; pH levels of holding solutions; humidity, temperature, air movement, and ethylene and carbon dioxide accumulations in storage chambers; respiration rates; use of chelating agents in holding solutions; and packaging and packing procedures. Investigations with woody ornamental plants concern storage and handling of bare-rooted evergreen nursery stock, the marketing of container-grown ornamental plants, and the packaging of selected woody ornamentals.

Numerous pathological investigations relate in part to the preservation of market quality in flowers and ornamentals.

Altogether there are 47 projects in 24 States that contribute in whole or in part to this area of research. Total market quality research effort on cut flowers and ornamentals at the State stations is approximately 11.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Quality maintenance in handling and packaging

1. Mistletoe. Mold on leaves and berries of inoculated prepackaged mistletoe was significantly greater when the mistletoe leaves and berries were injured than when they were free of injuries - suggesting the need for careful handling and packaging. Botran at concentrations of 2000 ppm controlled mold of prepackaged mistletoe in one test but failed to do so in two other tests. Alpha naphthalene acetic acid (20 ppm) when used with a fungicide was fairly effective in controlling leaf and berry abscission. (MQ 2-15)

B. Quality maintenance in storage

1. Pine Seedlings. Excessive desiccation and decay may cause serious losses in conifer seedlings during several months storage. Polyethylene bags were effective in retaining quality and freshness of pine and fir seedlings. Captan, Botran, and dibromotetrachloroethane controlled Botrytis, the chief cause of decay about equally well. (MQ 2-15)

2. Roses. Reducing the oxygen level to 0.5 percent was effective in extending the storage and market life of cut roses. The addition of 5.0 percent carbon dioxide to a low oxygen atmosphere was not beneficial and, in some instances, lowered bloom quality. Storage at 32° F. was better than storage at 36°. Responses to low oxygen atmospheres varied considerably among varieties. Placing rose stems in water during storage resulted in a rapid loss of quality even in the presence of low oxygen atmospheres. (MQ 2-15)

3. Carnations. In tests at Fresno, an atmosphere of 0.5 percent O₂ and 5.0 percent CO₂ was effective in holding both white and red carnations for 4 to 5 weeks at 36° F. The same atmosphere caused slight injury to the petals at 32°. Quality was maintained best when carnations were stored without placing the stems in water after cutting. (MQ 2-15)

4. Low Oxygen Effects. Tests, in cooperation with the Crops Research Division indicated little or no beneficial effect from storage of roses (at 60° F.) and chrysanthemums (at 33° F.) in atmospheres of 0% oxygen (100% nitrogen) or in 1% oxygen with 99% nitrogen, as compared with storage in air. Lilies kept better for 3 weeks at 33° F. in 100% nitrogen than in air, but the buds from either atmosphere failed to develop completely when placed at room temperature. Floret opening was retarded in gladiolus held 1 to 3 weeks at 40° but the greatest retardation was observed in atmospheres of 100% nitrogen and in 99.75% nitrogen with 0.25% oxygen. All glads stored 1 week at 40° failed to open completely when placed in air at room temperature. Dry storage of glads in sealed polyethylene bags was as satisfactory as any treatment tested. Daffodils responded well to storage in low oxygen atmospheres. After 3 weeks at 40° F. in air, daffodils had a vase life of about 40 hours at room temperature, whereas those held in 100% nitrogen at 40° lasted 90 hours, or as long as freshly cut flowers.

At 70° F., lily bulbs stored in air formed roots and sprouted within 2 months, whereas those stored in 1% oxygen with 99% nitrogen remained dormant for as long as 6 months. Subsequent forcing was satisfactory. Iris bulbs sprouted sooner in 1% oxygen with 99% nitrogen at 60° F. than those stored in air, but development of undesirable storage effects (very short stems and leaves) was delayed by low oxygen storage.

Geranium cuttings were stored successfully for 18 days at 32° F. in an atmosphere of 1% oxygen with 99% nitrogen. Growth resumed earlier than in those held in air or in 100% nitrogen. Geranium cuttings were stored successfully for 1 week and chrysanthemum cuttings for 6 to 8 weeks at 33° in sealed 1½ mil polyethylene bags. (MQ 2-105)

C. Quality maintenance during transportation

1. Roses. Packaging roses in film bags provides a way of maintaining modified atmospheres in air transit. In studies at Fresno, bags of roses were purged with nitrogen to rapidly lower the oxygen concentration. At 75° F., the resulting low oxygen level injured the blooms, stems, and leaves, but at 60° the level of oxygen was sufficient to maintain the flowers in excellent condition for 40 hours. Ethylene oxide (½ percent) added to the low oxygen atmospheres in the bagged red roses increased the undesirable blue color. Immersing the stems in aluminum sulfate solution before packaging favored the retention of the red color of the petals. However, low oxygen had a greater effect on red color retention than the sulfate dip. (MQ 2-15)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Quality Maintenance in Handling and Packaging

Smith, M. A. 1963. Control of Berry and Leaf Abscission and Mold Control in Packaged Mistletoe. Plant Disease Reprtr. 47:1001-1005. (MQ 2-15)

Quality Maintenance in Storage

Asen, Sam, C. S. Parsons, and N. W. Stuart. 1964. Experiments Aim at Prolonging Narcissus Display Life. Florists' Review, 134:25, 69-70. (MQ 2-105)

Quality Maintenance During Transportation

M. Uota and C. M. Harris. 1964. Quality and Respiration Rates in Stock Flowers. USDA, AMS 537. (MQ 2-15)

AREA 12

VEGETABLES - MARKET QUALITY

Problem. Most fresh vegetables are highly perishable. Research is needed on sources and time of infection and physical and chemical methods for decay reduction. Basic studies are needed on cell metabolism as related to the causes and control of functional disorders and the nature of ripening and aging. Product quality as related to mechanical harvesting will need increasing study as will the effects of storage environment on keeping and eating quality. Safe and effective transportation can be accomplished only by continued research with transportation services, equipment, and methods as these affect ultimate quality of the product in the market. The increasing interest in liquid gases for transit refrigeration and atmosphere modification has posed a series of new problems relating to effects on the commodities from release of substantial amounts of nitrogen or carbon dioxide in the load compartments. Additional information is needed on objective indices for harvest maturity and quality factors as related to standardization and grading, and practical measurements for quality changes as the product moves through marketing channels.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of applied and basic research relating to quality measurement and protection of vegetables as they pass through marketing channels. The work is conducted by horticulturists, plant pathologists, plant physiologists, and food technologists.

Research is conducted at USDA laboratories in Beltsville, Md.; Fresno, Calif.; Miami, Fla.; Orlando, Fla.; Belle Mead, N. J.; Chicago, Ill.; and Harlingen, Tex., and at the North Carolina Agricultural Experiment Station, Raleigh, N. C.

Of the 15.7 federal professional man-years devoted to this program, 2.2 are devoted to objective measurement of quality, 3.0 to quality maintenance in handling and packaging, 0.5 to storage, 2.5 to transportation, 3.0 to postharvest physiology, 4.0 to postharvest disease control, and 0.5 to program leadership.

Work terminated during the period included: cause and control of black leaf speck of cabbage (MQ 2-43); and decay of Florida endive, escarole, cabbage and celery (MQ 2-47).

PROGRAM OF STATE EXPERIMENT STATIONS

Much of the genetic, breeding, variety, and cultural research with vegetable crops at the State stations has as its ultimate aim an increase in market quality of the product. This research, however, is reported elsewhere. Considering only that research which applies to vegetables in the handling and marketing channels, there are 101 projects in 36 States concerned with market quality of vegetables. These projects deal with many phases of vegetable handling and marketing including cleaning vegetables prior to storage; methods of quality separation of vegetables; effects of transit, storage, prepackaging, and retail handling treatments on market quality; packaging methods and materials; senescence and microbe-inhibiting chemicals; hydrocooling; optimum storage environments; modified atmosphere storage; the effect of temperature on the ripening of vegetables; and the influence of storage environment on chemical and physical changes in vegetables.

The effect of handling and marketing treatments on the market quality of vegetables is determined by chemical and organoleptic tests. There is continuing research on the development of objective methods for measuring quality and correlating these methods with market acceptance. One regional project dealing specifically with this area of research is NEM-30, Quality Maintenance, Measurement, and Control in the Marketing of Vegetables Including Potatoes.

Numerous projects in Plant Pathology contribute in part toward market quality of vegetables. Several of these are concerned directly with transit, storage, and market diseases which affect the quality of vegetables.

Total market quality research effort on vegetables at the State stations is approximately 32.9 professional man-years.

Insect Control. A discussion of the program of the State Experiment Stations in this area is presented under Area 13, Insect Control in Marketing Channels - cross commodity.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Objective measurement of quality

1. Sweetpotatoes. Data obtained on a number of varieties and selections grown in North Carolina, Virginia, Mississippi and Maryland on the use of the USDA Skin Color Fan show generally good agreement among the states for the various varieties. (MQ 3-50)

2. Tomatoes. A survey of tomato juice quality from the major tomato processing areas of the United States shows no correlation between centrifuge solids and total solids. The Tomato Color Index computed by the USDA tomato colorimeter, appears favorable for defining the color of processed juice. (MQ 3-15)

B. Quality maintenance in handling and packaging

1. Cauliflower. Cauliflower wrapped in sealed, unperforated film may be severely injured when the concentration of CO₂ within the wrapper exceeds about 8%. This injury, which causes discoloration, excessive softening, off-flavors and off-odors upon cooking, is not evident in raw cauliflower. Four $\frac{1}{4}$ -inch holes in the film wrapper in which the individual heads were wrapped prevented a build-up of carbon dioxide. (Exploratory Research)

2. Lettuce. A delay of 9 hours between harvest and precooling during a hot day reduced the market quality of untrimmed lettuce slightly after holding 7 days at 36° or 41° F. Time of cutting and holding temperature had a greater influence on market quality than delay in cooling. Lettuce cut at 3 p.m. and held at 41° had more pink rib and russet spotting, and was of lower quality than lettuce cut at 9 a.m. and handled similarly. However, when lettuce was held at 35°, time of cutting had no measurable effect on quality.

The market quality of field-wrapped, market-wrapped, and naked-pack lettuce from the same field was compared at Fresno and New York under actual and simulated shipping conditions of 7 or 8 days at 32°, 37°, or 41° F. followed by 4 days at 50° F. Differences in external appearance were small in most tests and were not consistently in favor of either wrapped or naked lettuce.

The quality of western head lettuce prepackaged with seven different plastic films in New York, was evaluated after a simulated wholesale (3-4 days at 40° F.) and retail period (2-3 days at 70° F.). In three tests conducted, 33 percent visible decay occurred in the shrink-film wrapped heads and 22 percent in heads packaged with the non-shrink films. The heat shrinkable films used were polystyrene, polyethylene and polyvinyl chloride and the non-heat shrinkable films tested were cellophane and stretchable polyvinyl chloride overwraps, and 2 types of polyethylene bags. (MQ 2-58)

3. Rhubarb. By removing the leaf blade and wrapping the stalks in polyethylene, the storage and shelf life of rhubarb was increased significantly and the weight and package size reduced by one-third. Wrapped, de-bladed whole stalks were usable after 4 weeks at 32° F. plus 1 day at 70°, or 2 weeks at 40° plus 1 day at 70°. The shelf life of 1-inch stalk pieces packaged in polyethylene bags was about $\frac{1}{2}$ that of whole stalks. This work will be completed upon preparation of the report. (MQ 2-61)

4. Vacuum Cooling. Cooling was found to be most efficient when the pressure is reduced to 7.5 mm. Hg. quickly and held near 4.0 mm. Careful control of pressure with effective gauges prevented freezing near the end of the cooling cycle. Time tables were prepared for several crops packed in various types of containers and plastic films. (MQ 2-80)

C. Quality maintenance in storage

1. Asparagus Plants. Asparagus crowns stored at 32° F. for 3 months before planting gave highest yields of cut spears over a 3-year period when the roots were trimmed to 8 inches before storage. Roots trimmed to 4 inches yielded slightly less than untrimmed crowns. Polyethylene-wrapped crowns planted directly from cold storage gave yields comparable to burlap-wrapped crowns but when held for 6 days at 60° before planting, burlap-wrapped crowns gave significantly higher yields. (MQ 2-89)

2. Onions. More physiological breakdown (translucent scale) was found in onions delayed 15 days or longer after curing before storage than in those stored immediately. The disorder occurred mainly in onions 3 inches or larger in diameter and in onions maturing at high temperatures. Shading of the bulbs during growth reduced breakdown. The disorder occurred in onions grown on both peat and mineral soils. This work will be completed upon preparation of the report. (MQ 2-56)

3. Sweetpotatoes. Storage losses of sweetpotatoes stored in palletized field boxes was 11% vs. 20% in tub-bottom bushel baskets stored in the conventional manner, a savings of nearly 25 cents per bushel. Cool air drawn into the top of storage rooms at 1 to 2 cfm per bushel of storage capacity during late fall and early spring maintained storage temperatures at desired levels and decreased the temperature gradient within the rooms. This system of overhead ventilation was superior to the currently used system of introducing outside air at floor level and exhausting air at the top of the rooms. (MQ 2-73)

4. Mushrooms. Fresh mushrooms held for 3 days at 59° F. in 0 or 1/4 percent O₂ without CO₂ had almost no enlargement of the pileus, elongation of the stipe, or change in color, whereas those held in air continued to grow, open up, and darken. A slight amount of oxygen (1%) was necessary to prevent off-flavors. Mushrooms sealed in polyethylene bags, that were either purged with nitrogen before sealing or sealed with air in them, produced atmospheres with about 1/2 percent O₂ and 9 to 12 percent CO₂ after 4 days at 50° F. These atmospheres were effective in slowing growth, but the nitrogen purging resulted in a brown water-soaked appearance. (Exploratory research)

D. Quality maintenance during transportation

1. Asparagus. Although soft rot development in all-green asparagus was generally negligible during simulated rail transit, CO₂ levels of 5 and 10% held soft rot to less than 0.5%. Flavor or appearance of the cooked spears was not affected by these CO₂ concentrations under simulated refrigerated transit. Carbon dioxide levels of 10 to 50%, with O₂ above 5% during simulated air transit times of 24 hours at 36°, 41° or 50° F. significantly reduced the development of soft rot at the cut end of the spears during subsequent holding for 7 days in air at these same temperatures. This

effect was still evident after 2 additional days in air at 59°. Soft rot at the tip end was not affected by this brief exposure to CO₂. Spears were injured by 50% CO₂ in most tests and by 20 and 30% in one test. (MQ 2-13)

2. Lettuce. Liquid nitrogen as a substitute for or a supplement to mechanical refrigeration of piggyback trailers was tested with lettuce shipped from California to Chicago. Transit temperatures in trailers using only liquid nitrogen as a refrigerant averaged 3 to 5 degrees F. warmer than mechanically refrigerated trailers, in summer shipments. At destination, temperatures were frequently 7 to 15 degrees higher in the nitrogen units. Temperatures in trailers in which the nitrogen was used only to supplement the mechanical refrigeration were similar to mechanical units without nitrogen. Modification of the atmosphere in the trailers was quite variable, ranging from normal oxygen levels of 20% to as low as 3.8%. Carbon dioxide concentrations at destination were 1 to 2%. Quality was similar in lettuce shipped by the two methods in tests made to date, except for russet spotting which was only about one-half as severe in lettuce from trailers using nitrogen as that from companion trailers without nitrogen. (MQ 2-84)

3. Vine-Ripened Tomatoes. Since vine-ripened tomatoes are often shipped with other vegetables that require more refrigeration than tomatoes, experiments were conducted at Beltsville to determine possible adverse effects on tomatoes when exposed to temperatures below 50° F. Color development of tomatoes harvested after some red color was visible was sharply retarded by holding at 45°, 40°, and 32° for periods up to 6 days. Color development resumed promptly after the fruits were removed to 70° and the tomatoes eventually attained about the same degree of red color as those held at 70° continuously. Chilling injury did not occur during 6 days' holding at the low temperatures but did develop after 10 days at 32°. The more mature the fruits were at harvest the less subject they were to chilling injury. This project will be completed upon preparation of the report. (MQ 2-23)

E. Postharvest physiology

1. Effects of Low Oxygen. Tests at Harlingen, Texas showed that quality of cauliflower after 30 days in test atmospheres plus 7 days in air at 36° F. was best when the heads were held in 0.5 to 1% oxygen with carbon dioxide allowed to accumulate to an average of 11%. The external appearance of lettuce was good after 42 days storage in a test atmosphere at 36° of 0.5 to 1.0% oxygen plus gradual carbon dioxide build-up to 7.5%. However, severe internal browning (CO₂ injury) developed. This was eliminated when the evolved carbon dioxide was absorbed with lime. However, lettuce from the CO₂ free atmospheres looked no better than lettuce stored in air at the same temperature. Okra, after 11 days in test atmospheres at 45°, had the best quality when held in 10% carbon dioxide and 11% oxygen.

At Beltsville, lettuce and celery held 6 weeks at 33° F. remained in better condition in an atmosphere of 1% oxygen and 99% nitrogen than in air at this temperature. Decay and discoloration of the butts of both commodities were reduced in 1% oxygen.

After 5 days at 33° F., respiration (CO₂ evolution) of asparagus in 0% oxygen (100% nitrogen) was almost 50% less than it was in air. Holding asparagus in 1% oxygen and 99% nitrogen reduced respiration about 30% as compared to air. Respiration of mushrooms at 60° F. was reduced to 1/6 the rate in air after 4 hours at 0% oxygen (100% nitrogen). After 24 hours in 0% oxygen, the atmosphere was changed to air and respiration increased rapidly so that within 2 hours it had reached that of mushrooms held continuously in air. (MQ 2-71)

2. Chilling Injury of Eggplant. Low, but nonfreezing temperatures seriously affected the quality of eggplant fruits. Chilling injury, not apparent at the low temperature, developed rapidly when fruits were removed to 70° F. Fruits developed visible injury at 70° following 6 days at 32° or 40°. The injury increased sharply as the holding period was increased. Eggplant fruits top iced and stored at 45° for 7 days also developed serious chilling injury. (MQ 2-86)

F. Postharvest disease control

1. Chinese Cabbage. A 14-hour delay between harvest and precooling may occur in the handling of Florida vegetables. Florida-grown inoculated Chinese cabbage held 6 to 12 hours at 85° F. before precooling, developed bacterial soft rot within 1 week at 35° F. The longer the delay the greater the amount of decay. (MQ 2-47)

2. Irradiation of Vegetables. Gamma irradiation had no effect on the incidence of decay on artichoke buds, on five varieties of lettuce, or on sweet corn. Irradiation at 200 to 300 krad resulted in internal and external discoloration of artichoke buds, in brown spotting and death of lettuce leaves, and in increased denting of the kernels in sweet corn. Stem scar mold of cucumbers and summer squash was significantly reduced by 300 krad, but the treatment caused undesirable softening and yellowing. Sweetpotatoes were severely injured by 25 krad or more. Sprouting was inhibited by 8.25 krad during a subsequent 6 months' storage period, with only a very slight increase in decay. Irradiation greatly increased the susceptibility of sweetpotatoes to chilling injury. This work will be completed upon preparation of a report. (MQ 2-82)

3. Onions. After 4 months' storage, New York-grown Downing Yellow Globe onions harvested from plants spaced 5 per foot in single rows in the field developed 4.7 percent Botrytis neck rot; those spaced 13 plants per foot developed only 2.6 percent. In another test, decay averaged 26 percent from plots with 8 plants per foot, and about 1/2 as much decay from plantings spaced 13 plants per foot. The closely spaced onions had necks

of smaller diameter which were less subject to decay. None of the top-killing treatments, Diquot, Herbisan, or Penta were effective in reducing storage decay. (MQ 2-95)

4. Peppers. In tests in Texas, hot water (128° F. for 1½ minutes) or Phytomycin (100 ppm) gave fairly good control of bacterial soft rot of long-stemmed peppers, confirming results obtained previously. Chlorine (500 ppm) was much less effective. Adding chlorine (250 or 500 ppm) to hot water treatment improved decay control over that obtained with hot water alone. The benefits from any of these treatments were nullified when the treated peppers were subsequently hydrocooled, either without or with chlorine (500 ppm) in the water. Peppers with jagged stem-breaks collected in the field and packing shed, developed three times more soft rot infections than those with smooth breaks (abscission).

Brushes and toweling in the waxer apparently were the major source of infection in the packing line. Decay in peppers collected after waxing amounted to 51% compared with 11% in those collected before waxing. This work will be terminated upon completion of a final report. (MQ 2-87)

Low temperature appears to be the principal predisposing factor in the susceptibility of bell peppers to Botrytis rot. Decay of unwounded pepper pods increased sharply at 40° F. as compared to 50° confirming previous results. High relative humidity also favors decay. (MQ 2-52)

5. Sweetpotatoes. Shipping tests from North Carolina demonstrated that a 450 to 900 ppm Botran (2,6 dichloro-4-nitroaniline) dip controlled soft rot of sweetpotatoes during marketing as well as, or better than, the current commercial treatment employing SOPP (sodium o-phenylphenate). Botran caused less chemical injury to the sweetpotatoes and was easier to use in the packinghouse. A combination of hot water and SOPP was more effective than hot water alone and required only 1/5 the concentration of SOPP now used commercially. (MQ 2-73)

It has been reported in the literature that Rhizopus stolonifer produces a pectic enzyme, pectinmethylesterase, which plays an important role in the pathogenesis of the fungus in sweetpotatoes. Evidence obtained at Beltsville indicates that the enzyme is a product of the host rather than the organism. No evidence has as yet been obtained indicating a possible role of the enzyme in either pathogenesis by the fungus or disease-resistance by the host. (MQ 2-60)

6. Tomatoes. A dry, firm decay of mature green tomatoes caused by a bacterium was studied at Chicago. Physiological, pathological and histological studies indicate that the organism is an Enterobacteraceae and a strain of Aerobacter cloacae. (MQ 2-64)

Florida-grown mature-green tomatoes of Grothan Globe and Homestead varieties ripened more rapidly after harvest than those of the Indian River and

Manapal varieties. In addition, Grothan Globe and Homestead tomatoes were less subject to Alternaria decay following chilling than the slower ripening varieties, confirming previous results. Commonly used postharvest fungicides had little effect in the control of Alternaria decay of chilled tomatoes. (MQ 2-88)

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AREA 13

INSECT CONTROL IN MARKETING CHANNELS -- CROSS COMMODITY

Problem. There are over 100 kinds of insects, 15 or 20 extremely abundant and widespread, that attack agricultural commodities after harvest, in storage, during processing and transportation, and in wholesale and retail marketing distribution. They cause an annual loss of up to 1 billion dollars through feeding damage or by contamination that reduces quality and value of products. There is need for applied research to develop more effective, economical preventive and control measures that are safe and do not leave objectionable pesticide residues. There is also need for extensive basic research to provide a sound foundation for conducting applied studies, and to provide leads for developing new approaches to prevention and control.

USDA PROGRAM

The Department has a continuing program at Savannah, Georgia, involving entomologists and chemists engaged in basic and applied research directed toward the solution of problems of insect infestation, damage, and contamination of agricultural commodities and their manufactured or processed products in the marketing channels. The research is conducted in cooperation with the Entomology Research Division, the Field Crops and Animal Products Branch of the Market Quality Research Division, the Commodity Credit Corporation, the Armed Forces Pest Control Board, the United States Public Health Service, the Food and Drug Administration, and a number of individual firms and trade associations in the chemical, packaging, paper, synthetic film, food processing, and milling industries. Contributed funds to assist in the program were received from the U. S. Navy, the Commodity Credit Corporation, and firms in the chemical industry.

On a 1-year basis it was possible to engage entomologists at Fresno, California, in a special study of gamma irradiation effects on stored-product insects, utilizing a mobile Canadian irradiator and accompanying technical personnel made available through funds supplied by the U. S. Atomic Energy Commission

A grant to the University of Helsinki in Finland is for the study of post-harvest residues of pesticides in agricultural commodities. It became effective in 1960, continued to May 1964, and involved PL 480 funds with a \$56,637 equivalent in finmarks. It is in the process of negotiation for an extension.

A grant to the Central College of Agriculture, Warsaw, Poland, is for a study of the nutritional requirements of mites that attack agricultural products. It became effective in 1961, continues to February 1966, and involves PL 480 funds with a \$7,326 equivalent in Polish zlotys.

A grant to the Institute of Plant Protection, Poznan, Poland, is for the study of the insect pathogen, Bacillus thuringiensis, as a possible control measure against certain moths that attack stored products. It became effective in 1962, continues to May 1967, and involves PL 480 funds with a \$17,075 equivalent in Polish zlotys.

The Federal scientific effort in this program totals 19.2 professional man-years divided as follows: 3.4 on insecticide evaluation, 0.9 on insecticidal control, 4.7 on pesticide residues, 4.6 on nonchemical control, 3.6 on insect-resistant packaging, and 2.0 on program leadership at Hyattsville, Maryland.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The States have an effective research program in insect control on commodities in marketing channels. Principal emphasis is on stored-grain insects. Fundamental studies are in progress on the genetics, biology, ecology, and physiology of these pests. Life history studies are performed to determine the effects of environmental factors such as temperature, grain moisture, type of food, and influence of crowding on population development, behavior, and diapause. The mechanism by which these insects orient to food is also under investigation.

Relationships between storage fungi and stored-grain pests are being studied to determine the contribution insects make to losses caused by molds. Research is underway to establish the extent to which molds are disseminated and used as food by the insects. Various methods, including X-ray and microscopic examination of grains, are being used to determine the extent, time and place of occurrence of insect contamination. Harvesting methods and cleaning and storage facilities are being evaluated and the factors associated with the presence of contamination in different ecological situations are being determined.

Conventional chemical control studies involve the use of fumigants, protectants and surface treatments. These materials are evaluated for their effectiveness in insect control, influence on seed germination and amount of residue remaining after use under various moisture and temperature conditions. Application methods are tested to determine the most efficient method of administration in different types of storage facilities.

Cultural control methods, including sanitation and aeration, also are under investigation. The influences of dockage, cleaning, insect movement and other factors on these practices are being considered.

Natural resistance to stored-product insects in various types of grains is being evaluated and isolated for use in breeding programs to develop resistant varieties.

Investigations are also in progress on sex attractants, and the effects of high frequency electric fields and ionizing radiation for control of stored-product insects.

Research is being performed by the States on chemical and insect contamination of market crops, particularly processing tomatoes. Emphasis is placed on finding ways of eliminating insect contaminants and chemical residues in the field before harvest or in the processing plant. Various chemicals in different formulations are being evaluated for their effectiveness and residual properties.

A total of 13.4 man-years annually is devoted by the States to research on insect control in marketing channels.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Basic biology, ecology, and physiology

1. Nutritional Requirements of Mites. During the year, 46 artificial diets were studied, all based on components of the "Davis formula," and some to determine whether antimicrobial agents could be included in the diets without adverse effects on the mites. With Tyrophagus infestans, the addition of 0.2% of potassium sorbate or methyl para-hydroxybenzoate inhibited molds and bacteria without impairing mite development. Lack of sterols did not affect development of this mite. Mineral salt deficiencies generally only slowed down development, but potassium phosphate and calcium lactate were most essential of the salts tested for female fecundity. Eight of 16 amino acids tested were essential for development. Absence of asparagine or nucleic acid had little effect. Length of developmental period was normal in the absence of glutamic acid, glycine, proline, or serine, but mortality was high.

Carpoglyphus lactis continues to be difficult to rear on artificial diets, and the "Davis formula" is one of the best. A diet deficient in sterol delayed development, adult mites did not live long, and females laid no eggs. Neither sorbic nor benzoic acid had any distinct adverse effect on development. The species is extremely affected by diets deficient in amino acids, with proline absence causing the least effect. Adding acetic, lactic, succinic, formic, or citric acid to the Davis diet caused no improvement.

Acarus siro has markedly different nutritional requirements than the other 2 species studied. Absence of cholesterol or sterols seriously affect this species. It is also affected by diets deficient in the various amino acids and mineral salts. Analysis of a homogenate of A. siro showed 17 amino acids were present, with ornithine, leucine, and methionine in the largest amounts. (E21-AMS-1(a))

B. Insecticide evaluation

1. Contact, Residual, and Vapor Evaluations. There was 99.5% kill of adult rice weevils after exposure for 3 days to soft red winter wheat treated with 1 p.p.m. of dichlorvos. Kill was less than 80% when treated wheat was tested after aging 1 week, even with a dosage of 4 p.p.m. (MQ 1-15)

Of 37 compounds evaluated for contact, residual, and vapor toxicity, 31 were sufficiently effective in 1 or more of these actions to warrant further testing for potential use against stored-product insects. A special formulation for the slow release of malathion was more effective than a regular formulation during 12 weeks of aging. Of 13 compounds tested by topical application to Indian-meal moth larvae, 4 were sufficiently effective to warrant further evaluation. (MQ 1-23)

Daily applications of dichlorvos vapor for 5 months was highly effective in reducing the number of insects spreading from infested to uninfested stacks of flour in storage. The treatments also suppressed the number of insects moving from infested to uninfested bags of flour in the same stack. (MQ 1-24)

2. Fumigant Evaluation. Preliminary laboratory fumigation tests with 33 compounds showed 7 of them to be promising. Further tests with 6 of the 7 against at least 3 species of stored-product insects have established dosage-mortality regression lines. At the LD 95 level all 6 were more effective than methyl bromide that was used as a standard. Three other materials--crotyl bromide, acrylonitrile, and n-butyl isothiocyanate--gave promising results as fumigants for wheat in 1-gallon jars. Tests with the first 2 in laboratory fumigation towers filled with wheat showed relatively uniform penetration when forced distribution was used, but poor distribution by simple gravity penetration. (MQ 1-28)

C. Insecticidal control

1. Dichlorvos in Food Warehouses. Pressurized aerosol cylinders did not give as uniform distribution of dichlorvos concentrations in the air in warehouse treatments as did a vapor dispenser developed by researchers on

this project. Only trace amounts of dichlorvos, less than 0.1 p.p.m., were found in most food products exposed in a warehouse to 21 vapor applications. The residue in flour did not exceed 1 p.p.m. till after 21 applications. Residues tended to be slightly higher in several commodities when aerosol applications were used, but most residues dissipated fairly rapidly. The applications were made at weekly intervals with a dosage rate of 1.5 grams per 1,000 cubic feet, about the amount needed to give an air concentration of 4 micrograms per liter. The residue data from more than 2,500 analyses of food products and packaging materials were made available for inclusion in a petition to the Food and Drug Administration for dichlorvos tolerances on certain food products. (MQ 1-25)

D. Pesticide residues

1. Residue Analyses. Residue analyses were made on 9,864 samples involving 23 different products and 8 different insecticides. This is nearly a 50% increase in productivity over any previous year. An improved analytical method was developed to meet the need for more accurate malathion residue determination in walnuts, raisins, almonds, and cured tobacco. Studies to adapt gas chromatographic methods to methoxychlor residue analyses have developed a procedure giving promising results in the range of 1 to 20 p.p.m. in flour or paper. (MQ 1-29)

2. Fate of Residues in Fruits and Vegetables. CIPC (isopropyl N-(3-chlorophenyl) carbamate) and IPC (isopropyl N-phenyl carbamate) residues were found to be very stable. Less than 40% of the residues dissipated in preservation processes and their half-life was more than 6 months in water of pH 1 or 9 at 70° C. Storage tests with apples show that chemical injury to the apple skins caused by captan is related to the degree of maturity of the fruit. The metabolic degradation of the malathion molecule in plant tissues appears to be very complex, with the formation of numerous degradation compounds. Several of these products are known, but others remain to be identified. The importance of carboxyesterases and phosphatases in enzymatic degradation of malathion seems to vary greatly from one plant tissue to another. The degradation of malathion into water-soluble compounds was found to be the route of greatest disappearance of malathion residues from plant tissues. The degradation of malathion applied to gooseberries after harvest was found to be comparatively much slower when larger amounts were used. (E8-AMS-1(a))

E. Nonchemical control

1. Light. In tests with ultraviolet light peaked at 3660⁰Å, 71 to 82% of red flour beetle adults responded positively to intensities of 3 to 27 milliwatts per square centimeter, while 1 to 4% responded negatively. With the confused flour beetle, 26 to 48% of the adults did not respond at all

to intensities up to 5.4 microwatts per sq. cm., while those that did were photopositive, and light intensity seemed to be of no significance. Nearly 70 percent of adult cigarette beetles responded positively to all intensities up to 5.4 microwatts per sq. cm. At 4.9 and 5.4 microwatts per sq. cm., 7% of the adults were photonegative. In total darkness 80% of the cigarette beetle adults were quiescent. Rice weevil adults were not very responsive to intensities up to 5.4 microwatts per sq. cm., while 54 to 70 percent of merchant grain beetles were photopositive. The intensity of greatest attractancy varied with the species.

In tests with green light peaked at $5100\overset{\circ}{\text{A}}$, response of black carpet beetle larvae was increasingly negative with greater intensity, while that of confused or red flour beetles was increasingly positive. The response of cigarette beetle adults was affected very little by intensity. (MQ 1-12)

2. Sound. Extremely interesting results of great potential significance were obtained in recently initiated studies on the effect of sound on insect reproduction. So far as is known, this is the first research of this nature. Female Indian-meal moths were placed in a 150-cu.-ft. cabinet for 4 days, were provided medium for egg deposition, and were subjected constantly to sound waves from 2 speakers in the cabinet operating at less than 5 milliwatts output. Only about 1/4 as many moths developed from the medium in this cabinet as from a cabinet identical with the exception of the absence of speakers. Moths that did develop from eggs laid in the sound-treated cabinet took longer to mature than did those from the untreated check cabinet. (MQ 1-12)

3. Gamma Rays. Extensive data were developed on the gross effects of different dosages of gamma radiation on all stages of 8 species of stored-product insects and 1 mite species. The dosage range for sterility or mortality was between 10 and 100 kilorads, except for moths, which were more resistant. In general, the insects became more resistant as they developed from egg to larva, pupa, and adult, and as they became older within each stage. (MQ 1-12)

4. Biological Control. Laboratory experiments with E58 (a French product containing 54×10^9 spores per gram of Bacillus thuringiensis, Anduze strain) in wheat flour showed insecticidal effects of the bacteria against the Mediterranean flour moth. Exposures of 48 hours to the infective flour produced high mortality in newly emerged and older larvae, the rate of mortality being linearly related to the concentration of E58 in the flour. Newly emerged larvae that survived the exposure were transferred to untreated flour and mortality was 2 to 2.7 times that in untreated checks, the period of development to the adult stage for the survivors was twice as

long, the emerging adults were very small, and the females laid no eggs. Survivors from older larvae exposed 48 hours in infective flour required 2 to 9 days less than untreated larvae to become adults, none of which produced any progeny. There appeared to be no influence on effectiveness of the bacteria at different relative humidities or at temperatures between 15 and 26° C. during 21-day exposures of larvae to infective flour. Comparative tests with spore preparations from 3 different sources showed that the Plantibac material produced higher mortalities than did E58.

(E21-AMS-4(a))

F. Insect-resistant packaging

1. Repellent Evaluation. Preliminary testing of 55 compounds revealed 2 more effective than the synergized-pyrethrum standard. These were du Pont Repellent 887 (ENT-26855) and DRC-2104 (a diphenylamine-acetone reaction product). (MQ 1-20)

2. Residue Barriers. A polyvinyl fluoride film, glassine, greaseproof paper, and several saran films and coatings prevented migration of malathion from a surface treatment into flour in a laboratory test. The polyvinyl fluoride film and the saran films and coatings were also effective barriers against the migration of piperonyl butoxide. Common packaging films such as polypropylene and cellophane were not effective barriers. Migration of methoxychlor was less from an oil-free paper coating than from one containing oil, indicating that grease resistance of packaging films may be a factor in preventing migration. At the end of a 9-month test with small bags, those with a migration barrier of mylar film had slightly more piperonyl butoxide remaining in the outer coating than did those without the film. (MQ 1-1 (Rev.))

3. Storage Tests. Commodities were stored for 18 months in standard multi-wall paper bags, the outer ply of which were treated with a coating containing 5 mg. of pyrethrins and 50 mg. of piperonyl butoxide per square foot. Chemical analysis for piperonyl butoxide showed 6.3 p.p.m. in flour, 5.5 in rice, 4.74 in nonfat dry milk (these bags had an additional polyethylene liner as a moisture barrier), and 0.6 in dry beans. All residues were well below the previous temporary tolerance of 10 p.p.m., and the data have been submitted to the Food and Drug Administration for consideration in a petition for establishment of a permanent tolerance. Multiwall bag closures with a stepped end folded and sealed with a hot-melt adhesive eliminate needle stitching, which is one of the primary avenues for insect invasion. Tests with flat and gusset bags having this closure and an outer coating of a repellent treatment gave promising results in storage tests, even with the gusset bag into which it has previously been impossible to incorporate any satisfactory degree of insect resistance. (MQ 1-17)

Storage tests of small bags treated with 9 compounds that had been promising in preliminary repellency tests showed that they were not as effective as the standard in this type of exposure. A small-bag test with an extender for pyrethrins showed it to be about equally as effective as the standard. Small bags of kraft paper or polyethylenelene coated with a silica aerogel were heavily penetrated during a 9-month storage test. (MQ 1-21)

4. Physical Resistance of Packages to Insect Invasion and Penetration.

Eighteen flexible synthetic film packaging materials were tested for insect penetration and one of polycarbonate was highly resistant during 24 months of exposure. In other tests an aluminum foil-kraft paper laminate and a 2-mil polyamide film appeared promising for resisting insect penetration. The "Van Buren" closure for small shell cartons was found more resistant to insect invasion than was the "web" closure, and adding synergized pyrethrum to the overvarnish on the carton increased the resistance to invasion.

(MQ 1-22)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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AREA 14

INSTRUMENTATION FOR OBJECTIVE MEASUREMENT OF MARKET QUALITY

Problem. Agricultural commodities vary widely in many of the factors that determine market quality. A continuing need exists for more and better instruments for use in the marketing of agricultural commodities. This need includes instruments to measure color, moisture content, texture, maturity, composition; and to detect defects in a wide range of commodities. These instruments are needed by inspection and grading services, by food handlers and processors, and by research workers in the broad field of agricultural marketing. The development of techniques of measurement suitable for use in automatic sorting is included in this area. The rapid conversion to mechanical handling of agricultural commodities makes it imperative that automatic devices be developed to evaluate and control the quality of the product.

USDA PROGRAM

The Department has a continuing program involving engineers and physicists engaged in the broad field of instrumentation, procedures and methods for use in basic and applied research on market quality of agricultural products. This work supplements other marketing research through superior instrumentation designed for the specific problem under study, and is cooperative with other units of the Division.

The Federal scientific effort devoted to research in this area totals 5 professional man-years.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

The State stations have a continuing program of research directed to developing objective measures of quality of a number of agricultural commodities and products. A considerable portion of this research is conducted, however, as parts of studies which have other objectives such as identifying quality factors, measuring the effects of production practices on quality or developing better methods for handling and storage of agricultural commodities.

One study is designed to investigate various means of sampling and inspecting apples for processing and to develop practical methods for use of Federal-State inspectors. Another study seeks to develop and standardize

a reliable objective method for evaluating potato texture and to apply it in potato studies. Still another project aims to develop reliable objective methods for measuring carcass traits which may be correlated with quality and quantity of beef.

Considerable effort is devoted to study of the relationships between objective measurements and subjective evaluations of food quality. The aim is to apply both objective and subjective procedures to evaluate initial product quality, changes in quality during processing or retention of quality during handling, storage and distribution to the consumer.

A Northeastern regional marketing project, NEM-30, entitled Quality Maintenance, Measurement and Control in the Marketing of Vegetables Including Potatoes, has as its first objective: To develop objective methods for measuring quality, correlate these with market acceptance, and utilize these methods in developing grades and standards and quality control procedures. For example, work under the Maryland contributing project will involve development of new attachments to the shear-press which will provide simpler, less expensive cells for measuring the tenderness-maturity factor of raw vegetables. Other research involves development of objective chemical and physical measures which will facilitate measurement of individual product characteristics or over-all product quality.

A total of about 11.0 professional man years is devoted by the States to research on instrumentation for objective measurement of market quality.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Moisture Measurement. Work has continued on the development of the infrared-absorption method for measurement of moisture content. The spectral transmittance and reflectance characteristics in the near infrared have been measured for a number of grains and seeds using specially built equipment. The relationship of these properties to the moisture content has been studied to determine the optimum conditions for measuring moisture content. The water-absorption bands in organic and inorganic materials have been studied to help understand the effects observed in grain. At the present time, we do not have sufficient knowledge of all the factors involved, and the effort is continuing toward the development of a sound theoretical basis for the measurements.

2. Fruit and Vegetable Quality Measurements. The Interior Quality (I. Q.) Sorter has been tested on apples and the classifications compared for eating quality at harvest time, storage life, and eating quality after storage. Sorting on the basis of $\Delta O D$ (740 - 695nm) gave good results on the four varieties of apples used in the tests (Golden Delicious, Red Rome, Stayman,

and Winesap). The performance was adequate to justify the development of a commercial scale unit for automatic sorting of newly harvested apples.

The I. Q. Sorter has also been tested for automatic sorting of potatoes for hollowheart. Classifications based on $\Delta O D$ (820 - 710 nm) were in good agreement with internal appearance, indicating that automatic sorting of potatoes is technically feasible if the cost can be justified.

Variables influencing the light-transmittance measurements for indicating quality have been studied. In the detection of brown substances in fruit, the chlorophyll content is an important variable. A system has been developed whereby the chlorophyll content can be evaluated simultaneously with the measurement for browning; thus, it is feasible to correct the browning measurement for the chlorophyll content. Size of the fruit is a factor in the light-transmittance measurements in some cases and a system was developed to measure the size of the fruit and correct the light-transmittance measurement for size when necessary.

3. New Instruments. Three abridged spectrophotometers have been constructed to measure the optical density of biological materials at four wavelengths and compute the optical-density difference between any two wavelengths.

(a) Horticultural Difference Meter. With the capability of measuring at four wavelengths at one time, it is possible to measure more than one attribute of quality at the same time. In the case of apples, it would be possible to evaluate maturity (as a function of the chlorophyll content), water core, and internal browning. Since these quality factors are interrelated (as far as light transmittance is concerned), it is possible to evaluate these factors more accurately than has previously been possible when making a rapid measurement with a difference meter. Also, the instrument incorporates a method of measuring size and a means of making a size correction on the transmittance measurement.

(b) Phytochrome Difference Meter. A new four-filter photometer has been designed and constructed for detecting phytochrome in plant tissues and extracts. This instrument provides greater sensitivity and stability than the previous models and permits independent analysis for both the red-absorbing and far-red-absorbing forms of phytochrome.

(c) Infrared Difference Meter. A four-filter photometer unit has been constructed for measurements in the near infrared region. This instrument is a multipurpose unit, but it is designed for measuring the moisture content of grain and seeds by measuring the absorption at one of the OH-absorption bands of water.

The Interior Quality Sorter, developed under a research contract, has been modified to convert to a four-filter measurement with improved accuracy. New electronic techniques have been incorporated to improve the versatility and reliability. This machine can now sort for two internal quality factors at the same time. It is expected to have its greatest value in sorting of apples for maturity and detecting those containing water core.

B. Biophysics

1. Photosynthesis. Dark-grown bean leaves were examined during early stages of greening to determine when the photosynthetic apparatus began to function, and to correlate the onset of activity with specific pigments or pigment changes in the leaf. Measurements of fluorescence yield showed the first indication of photosynthetic electron transport after 2 hours of illumination. At this same time, the first indication of chlorophyll b and chlorophyll a-680 were shown by low-temperature derivative absorption spectroscopy. Low-temperature fluorescence-excitation spectroscopy showed the first indication of C-705 at this same time. The pigment changes suggest the mobilization of pigments into the two photosynthetic pigment systems. Photosynthetic activity in the greening leaf awaits the mobilization of the two systems.

Measurements of the fluorescence-yield changes on mutant strains of algae having abnormal photosynthetic responses gave additional evidence for the two-pigment concept.

Freezing and thawing experiments on dark-grown bean leaves resulted in shifts to shorter wavelengths for the photochlorophyll and newly-formed chlorophyll absorption bands. Similar shifts are observed naturally in 10 to 30 minutes if the leaves are not frozen. These spectral shifts are ascribed to disaggregation resulting from structural changes in both the normal condition and in the freezing and thawing experiments.

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of Biology, 39(1): 6-10.

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AREA 15. PIONEERING RESEARCH - MARKET QUALITY

Problem. Fresh fruits and vegetables are living organisms that continue many vital processes after harvest. These processes involve biochemical and physiological changes and activities. Rate of ripening, aging and susceptibility to disease are factors greatly influencing the storage and marketing life and the quality of fruits and vegetables. Since fundamental processes in the plant tissues in a large measure govern these changes a continuing need exists for more basic information on postharvest physiology, including enzymatic activities, the biosynthesis and function of various natural occurring volatiles, reactions of mitochondria including the electron transport chain, the cytochromes, and other activities associated with respiration. This information should furnish a basis for a better understanding of the fundamental behavior of agricultural commodities, and result in improved quality in the products that reach the consumer.

USDA PROGRAM

The Department has a continuing program at Beltsville, Maryland, involving plant physiologists and chemists engaged in basic studies directed toward developing information on the physiological and biochemical changes that occur in fruits and vegetables and other plant material after harvest under conditions that may be encountered in transportation, storage and marketing. This work supplements and is cooperative with other marketing research in the Division.

The Federal scientific effort devoted to research in this area totals 3 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Postharvest Physiology

1. Biosynthesis of Ethylene. The physiological action of ethylene in triggering and accelerating the ripening process in fruit has been observed for over 50 years, but its origin in plant tissues has been unknown. Work with model systems and cytoplasmic particles from fruit tissues has established that linolenic acid, when properly peroxidized, can react with ferrous iron to produce the complete series of saturated hydrocarbon gases from methane to hexane. The gas produced in greatest amount is ethane. However, when cuprous copper is substituted for iron in these systems ethylene is the major hydrocarbon gas produced. Experiments with tissue slices show that ethylene production is severely curtailed by inhibitors of copper enzymes and that anti-oxidants, such as propyl gallate, also

strongly inhibits ethylene formation by tissue slices. Propyl gallate prevents oxidation of polyunsaturated fatty acids which is a necessary prerequisite to ethylene production in the model system. These experiments suggest a possible origin of ethylene and a biochemical pathway for its production in tissues and a new chemical reaction which can degrade polyunsaturated fatty acids to hydrocarbon gases. The reaction also gives rise to hydrocarbon gases from a number of more simple substrates. Such reactions may be responsible for the production of hydrocarbon oils and gases from polyunsaturated fatty acids derived from prehistoric animals. It may be possible to produce simple substrates from agricultural commodities and convert them to methane, ethane, and ethylene. (MQ P-1)

2. Ethylene Production by *Penicillium Digitatum*. In cooperative studies with the Horticultural Crops Branch, it was found that *Penicillium digitatum* produces a maximum amount of ethylene after the maximum growth and respiration rates have occurred. This suggests a relation of ethylene production to senescent tissue metabolism in *P. digitatum* as well as in fruit tissues. The stimulation of ethylene production by the addition of yeast extracts to the cultures of *P. digitatum* was found to be related to the thiamine and biotin content but not to the amino acids in the extract. The stimulating factors were partially destroyed during autoclaving the extract and were partially removed by passage through a cation exchange resin (Dowex 50). The activity was not removed by ether extraction. (MQ P-1)

3. Respiration of Potato Slices. It was found that ethylene oxide and DIECA (a copper enzyme inhibitor) inhibit the respiratory rise in potato slices during the first 18 hours after cutting. Although not conclusive, this evidence points to a role for ethylene in controlling metabolism in this tissue. Two unknown gases were demonstrated in the emanations of aged slices which are not produced by freshly cut slices. (MQ P-1)

4. Hematin Compound in Peanuts. In a cooperative study with the Instrumentation Laboratory, a hemoprotein in ungerminated as well as germinating peanuts was found to be a catalase-type of hemoprotein. It is associated exclusively with the lipid fraction and may provide a protective action on the lipid during storage of the peanut. (MQ P-1)

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

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- Craft, C. C. 1963. Respiration of Potatoes as Influenced by Previous Storage Temperatures. Am. Potato Jour. 40: 289-298. (MQ P-1)
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Line Project Check List -- Reporting Period October 1, 1963 to September 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area and Subheading
MQ 1	Methods for the prevention and control of insects attacking agricultural products in the marketing channels. Program Leadership	Hyattsville, Md.		
MQ 1-1 (R)	Packaging insecticide formulation studies	Savannah, Ga.	Yes	13-F-2
MQ 1-6	Fumigation studies on cheese mites		No	
MQ 1-7	Ecology of stored-tobacco insects	Richmond, Va.	Yes	11-A-1
MQ 1-9	Infrared rice dryers for insect control		No	
MQ 1-10	Fumigation of stored tree nuts*		No	
MQ 1-12	Physical energy for detecting and controlling insects	Savannah, Ga. Fresno, Calif.	Yes	4-B-3 13-E-1,2,3
MQ 1-13	Packaging for dry milk*		No	
MQ 1-15	Laboratory evaluation of protectants for commodities	Fresno, Calif. Tifton, Ga. Savannah, Ga.	Yes	3-G-1 4-C-2 6-C-1 13-B-1
MQ 1-16	Forced-distribution fumigation of grain in commercial storages		No	
MQ 1-17	Storage tests of insect-resistant packages	Savannah, Ga.	Yes	13-F-3
MQ 1-18	Effects of air movement on stored-grain insects	Manhattan, Kans.	Yes	4-C-1
MQ 1-19	Protective treatments for rough rice		No	
MQ 1-20	Preliminary evaluations of compounds for insect-resistant packages	Savannah, Ga.	Yes	13-F-1
MQ 1-21	Preliminary storage tests of insect-resistant package treatments	Savannah, Ga.	Yes	13-F-3
MQ 1-22	Physical resistance of packages to insects	Savannah, Ga.	Yes	13-F-4
MQ 1-23	Preliminary evaluation of insecticides	Savannah, Ga.	Yes	6-C-2 13-B-1
MQ 1-24	Development of aerosol and mist spray formulations	Savannah, Ga.	Yes	13-B-1
MQ 1-25	Spray application studies for warehouses	Savannah, Ga.	Yes	13-C-1
MQ 1-26	Laboratory evaluation of moth-proofing compounds	Savannah, Ga.	Yes	8-B-1
MQ 1-27	Intermediate evaluation of grain protectants		No	
MQ 1-28	Laboratory evaluation of fumigants for stored-product insects	Savannah, Ga.	Yes	13-B-2
MQ 1-29	Determination of chemical residues	Savannah, Ga.	Yes	13-D-1
MQ 1-30	Insect damage to stored corn in the Southeast* (C)	Auburn, Ala.	Yes	4-C-3
MQ 1-31	Preconditioning stored-product insects to fumigants	Manhattan, Kans.	Yes	4-C-1
MQ 1-32	Studies of natural attractants in dermestids		No	
MQ 1-33	Effects of fumigant residues on quality of tobacco**	Richmond, Va.	Yes	11-A-2
MQ 1-34	Controlling insects in and around fruit processing plants	Fresno, Calif.	Yes	3-G-2
MQ 1-35	Toxic and repellent materials for cigarette beetles	Richmond, Va.	Yes	11-A-2
MQ 0-0-1	Treatments and procedures for preventing loss of CCC grain through insect attack	Manhattan, Kans. Watseka, Ill.	Yes	4-B-1 4-C-1,4
	*Discontinued during reporting period			
	**Initiated during reporting period			

Line Project Check List -- Reporting Period October 1, 1963 to September 30, 1964

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area and Subheading
MQ 2	Maintaining and improving agricultural product quality in storage, transportation, and handling. Program Leadership	Hyattsville, Md.		
MQ 2-7 (R)	Control of deterioration of rough rice	College Sta., Tex.	Yes	4a-B-1
MQ 2-12	Storage of plums	Fresno, Calif.	Yes	3-C-2
MQ 2-13	Modified atmospheres, containers, transit services on asparagus	Fresno, Calif.	Yes	12-D-1
MQ 2-15	Cut flowers and ornamentals	Chicago, Ill. Fresno, Calif.	Yes	11b-A-1 11b-B-1,2,3 11b-C-1
MQ 2-16	Softening of brined cherries*		No	
MQ 2-22	Decay control in Eastern peaches*		No	
MQ 2-23	Maintaining quality of vine ripened tomatoes	Beltsville, Md.	Yes	12-D-3
MQ 2-24	Pre-harvest infection of citrus fruit and post-harvest decay	Pomona, Calif.	Yes	1-D-1
MQ 2-29	Detection and description of freezing injury		No	
MQ 2-31	Chemicals for control of sprouting	Beltsville, Md. Presque Isle, Me.	Yes	9-C-3
MQ 2-33	Packaging Eastern peaches and nectarines		No	
MQ 2-35	Ventilation on quality of Maine potatoes*		No	
MQ 2-39	Prestorage treatments of potato diseases*		No	
MQ 2-40	Storage and shelf life of Persian limes*	Miami, Fla.	Yes	1-D-5
MQ 2-41	Maintenance of quality of poultry in S.E. States	Athens, Ga.	Yes	10-B-1,2
MQ 2-42	Loading methods and protective services for Maine potatoes	Presque Isle, Me.	Yes	9-D-2
MQ 2-43	Black leaf speck of cabbage*		No	
MQ 2-44	Long term storage of vegetable oils	Washington, D. C.	Yes	6-B-2
MQ 2-45	Modified atmospheres for berries	Beltsville, Md.	Yes	3-F-3,5
MQ 2-46	Ripening of mangos and avocados*	Miami, Fla.	Yes	1-B-1
MQ 2-47	Decay of Florida endive, escarole, cabbage, celery*	Orlando, Fla.	Yes	12-F-1
MQ 2-48	Controlled atmosphere storage of citrus*	Harlingen, Tex.	Yes	1-B-2
MQ 2-49	Sulphur dioxide treatment of grapes*	Fresno, Calif.	Yes	3-C-4
MQ 2-50	Market quality Southeastern potatoes*		No	
MQ 2-52	Gray mold of peppers	Beltsville, Md.	Yes	12-F-4
MQ 2-53	Precooling and transporting Florida Citrus fruits and vegetables	Orlando, Fla.	Yes	1-C-2
MQ 2-55	Transit temperatures - California potatoes	Fresno, Calif.	Yes	9-D-1
MQ 2-56	Physiological breakdown in stored onions	Fresno, Calif.	Yes	12-C-2
MQ 2-57	Controlled atmospheres for Western apples		No	
MQ 2-58	Market quality of Western lettuce	Fresno, Calif. Belle Mead, N.J.	Yes	12-B-2
MQ 2-59	Market diseases of cucurbits		No	
MQ 2-60	Host-parasite physiology of market diseases	Beltsville, Md.	Yes	12-F-5
MQ 2-61	Antioxidants, metabolic inhibitors on vegetables	Beltsville, Md.	Yes	12-B-3
MQ 2-62	Deterioration of grass seed	Beltsville, Md.	Yes	4b-B-1
MQ 2-63	Plastic film for Eastern fruit	Beltsville, Md.	Yes	3-B-1 3-C-1
MQ 2-64	New market diseases	Chicago, Ill.	Yes	12-F-6
MQ 2-65	Post-harvest diseases Florida citrus	Orlando, Fla.	Yes	1-D-2
MQ 2-66 (C)	Control of pear scald	Corvallis, Ore.	Yes	3-E-3
MQ 2-67	Forecasting storage diseases of apples	Wenatchee, Wash.	Yes	3-F-1
MQ 2-68	Anthracoise of avocado and mango fruits*	Miami, Fla.	Yes	1-D-4

Continued next page

Line Project Check List -- Reporting Period October 1, 1963 to September 30, 1964 cont'd

Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area and Subheading
MQ 2-69	Influence of storage temperature on processing quality of potatoes	E. Grand Forks, Minn.	Yes	9-C-1
MQ 2-70	Evaluation and prevention of deterioration of corn in storage		No	
MQ 2-71	High nitrogen or carbon dioxide in shipments of fruits and vegetables	Beltsville, Md.	Yes	3-D-2
MQ 2-72	Lenticel spot of Golden Delicious apples	Harlingen, Tex.	Yes	12-E-1
MQ 2-73	Reducing injury, decay, and shrinkage of sweet-potatoes	Wenatchee, Wash.	Yes	3-E-4
MQ 2-74	Spoilage and quality of Florida grapefruit on European markets	Raleigh, N. C.	Yes	12-C-3
MQ 2-75	Methods for maintaining meat quality	Chicago, Ill.	Yes	12-F-5
MQ 2-76	Cause and prevention of heat damage in rough rice	Orlando, Fla.	Yes	1-C-1
MQ 2-77	Cause and prevention of damage and off color in rough rice	Beltsville, Md.	Yes	5-B-1
MQ 2-78	Bruising of Red River Valley Potatoes during handling into storage	College Sta., Tex.	Yes	4a-C-1
MQ 2-79	Respiration of citrus fruit in relation to rind breakdown	La., Ark.	Yes	4a-C-2
MQ 2-80	Vacuum cooling prepackaged vegetables	College Sta., Tex.	Yes	9-B-1
MQ 2-81	Quality retention of eviscerated poultry	La., Ark.	No	
MQ 2-82	Gamma radiation on market life of fruits and vegetables	E. Grand Forks, Minn.	Yes	
MQ 2-83	Transit environments on Western strawberries		No	
MQ 2-84	Transit refrigeration of Western fruits and vegetables in mechanically refrigerated cars and trailers	Fresno, Calif.	Yes	12-B-4
MQ 2-86	Chilling injury of eggplant**	Beltsville, Md.	Yes	10-B-3
MQ 2-87	Control of bacterial soft rot in bell peppers	Fresno, Calif.	Yes	1-D-3
MQ 2-88	Ripening of Florida-grown tomatoes		Yes	3-F-6
MQ 2-89	Storage of asparagus crowns		Yes	12-F-2
MQ 2-90	Effects of heat treatment on potato diseases**		Yes	3-D-1
MQ 2-91	Apple and pear scald		Yes	3-F-4
MQ 2-92	Ventilation rates and relative humidity on storage quality of potatoes**	Fresno, Calif.	Yes	12-D-2
MQ 2-93	Prestorage environment and handling conditions on Maine potatoes**		Yes	
MQ 2-94	Composition, maturity, and deterioration of blue-berries**		Yes	
MQ 2-95	Control of decay of onions in storage**		Yes	
MQ 2-96	Radiation on pathogenicity of fungi**		Yes	
MQ 2-97	Proteolytic enzymes in relation to market decay**		No	
MQ 2-98	Texas grapefruit and California oranges in controlled atmosphere storage**		Yes	
MQ 2-99	Controlled atmosphere storage for stone fruits**		Yes	
MQ 2-100	Components of citrus rind affecting decay organisms**		No	
MQ 2-101	Infection of table grapes**		No	
MQ 2-102	Ozone on fruits and vegetables**		Yes	
MQ 2-103	Development of mycotoxins in peanuts and rice**		No	

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area and Subheading
MQ 2-104	Heat treatments to control decay of fruits	Beltsville, Md.	Yes	3-F-4
MQ 2-105	Controlled-atmosphere storage of ornamentals	Beltsville, Md.	Yes	11b-B-4
MQ 0-0- 2 (C CC)	Corn deterioration in storage	Watseka, Ill.	Yes	4-B-2
MQ P-1	Pioneering Research Post Harvest Physiology *Discontinued during reporting period **Initiated during reporting period	Beltsville, Md.	Yes	Area 15

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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area and Subheading
MQ 3	Basic research on quality evaluation and development of objective measurement of quality factors in agricultural products. Program Leadership	Hyattsville, Md.		
MQ 3-1	Development of a small scale spinning test*	Washington, D. C.	Yes	7-A-1
MQ 3-3	Quality indicators for stored wheat	Clemson, S. C.	Yes	4-A-1
MQ 3-11	Screening tests for pesticide residues in dairy products*	Kansas City, Mo.	Yes	2-A-1
MQ 3-12	Identification of rice varieties*	Beltsville, Md.	Yes	4a-A-1
MQ 3-13	Relation of spinning performance of cotton to color grade*	Beltsville, Md.	Yes	7-A-2
MQ 3-14	Quick dye methods for determination of protein content of milk	Lubbock, Texas	Yes	2-A-2
MQ 3-15	Evaluating quality of tomatoes for processing	Davis, California	Yes	12-A-2
MQ 3-16	Measurements for determining the degree of milling of rice	College Sta. Tex.	Yes	4a-A-2
MQ 3-17	Relation of cotton fiber properties to yarn strength	Washington, D. C.	Yes	7-A-3
MQ 3-18	Detection of damage by heat in artificially dried corn	Raleigh, N.C.	Yes	4-A-2
MQ 3-20	Seasonal changes and metabolic activity of oranges	Beltsville, Md.	Yes	1-A-1
MQ 3-21	Mechanization of seed purity analysis	Orlando, Fla.	Yes	4b-A-1
MQ 3-22	Disease syndromes of market poultry	Riverside, Calif.	Yes	10-A-1
MQ 3-23	Determination of moisture in grain, seeds and oilseeds	Corvallis, Ore.	Yes	4-A-3
MQ 3-24	Equipment for sampling and grading small grains and soybeans	Beltsville, Md.	Yes	4b-A-2
MQ 3-25	Oil quality changes in long term storage	Beltsville, Md.	Yes	4-A-4
MQ 3-26	Defect evaluation of peanuts	Washington, D. C.	Yes	6-B-3
MQ 3-27	Quality measurement of red tart cherries	Beltsville, Md.	Yes	6-A-2
MQ 3-28	Quality measurement of apples	College Sta. Tex.	Yes	3-A-3
MQ 3-29	Methods and equipment for grading farmers' stock peanuts	Beltsville, Md.	Yes	3-A-1,2
MQ 3-30	Lighting system for grain inspection	Beltsville, Md.	Yes	6-A-1
MQ 3-31	Assessing the sanitary quality of commercial egg solids	Raleigh, N. C.	Yes	4-A-5
MQ 3-32	Seed metabolism	Beltsville, Md.	Yes	10-A-2
MQ 3-33	Effects of production, harvesting, and ginning practices on spinning performance and cotton quality.	Beltsville, Md.	Yes	4b-A-3
MQ 3-34	Evaluating market quality of livestock and meat	Clemson, S. C.	Yes	7-A-4,5
MQ 3-36	Measurement of flour yielding capacity of wheat	Beltsville, Md.	Yes	5-A-1,2
MQ 3-38	Maturity determinations in Italian prunes	Beltsville, Md.	Yes	4-A-6
MQ 3-39	Physical techniques for determining purity of grass seeds	Beltsville, Md.	No	
MQ 3-40	Determining susceptibility of potatoes to bruising	College Sta. Tex.	Yes	4b-A-4
MQ 3-41	Rapid method for determining moisture of grass and hay	College Sta. Tex.	Yes	4b-A-5
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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area and Subheading
MQ 3-42	Surface contamination of cotton fibers	Clemson, S. C.	Yes	7-A-6
MQ 3-43	Measuring the frictional properties of cotton fibers	Clemson, S. C.	Yes	7-A-7
MQ 3-44 (C)	A study of methods for grading milk	St. Paul, Minn.	Yes	2-A-3
MQ 3-45	Rapid measurement of refining loss in cottonseed oil	Washington, D. C.	Yes	7-B-1
MQ 3-46	Aromatic polynuclear hydrocarbons in or on citrus fruit	Pomona, Calif.	Yes	1-A-2
MQ 3-47	Evaluation of cotton fiber testing instruments	Clemson, S. C.	Yes	7-A-8
MQ 3-48	Automatic alternating temperature seed germinator	College Sta. Tex.	Yes	4b-A-6
MQ 3-49	Predicting keeping quality of anhydrous butter fat**	Beltsville, Md.	Yes	2-A-4
MQ 3-50	Fresh product factors to processed quality in sweetpotatoes	Beltsville, Md.	Yes	12-A-1
MQ 3-51	Reevaluation of official cottonseed standards**	Washington, D. C.	Yes	7-B-2
MQ 3-52	Lighting for grading and inspection of poultry**	Beltsville, Md.	Yes	10-A-3
MQ 3-53	Seasonal changes in Florida Persian limes**		No	
MQ 3-54	Techniques for handling grass seeds for analysis**	College Sta. Tex.	Yes	4b-A-7
MQ 3-55	Physiological and biochemical factors in seedling vigor**	Beltsville, Md.	Yes	4b-A-8
MQ 3-56	Raw product factors and processed quality in potatoes**	Beltsville, Md.	Yes	9-A-1
MQ 3-57	Microstructure and keeping quality of butter**		No	
MQ 3-58	Measuring protein content of grain sorghum**		No	
MQ 3-59	Lighting requirements for evaluating meat quality**		No	
MQ 3-60	Marbling and palatability of beef**	Beltsville, Md.	Yes	5-A-3
MQ 3-61	Flavor and palatability of beef**	Beltsville, Md.	Yes	5-A-4
MQ 3-62	Standards for maturity evaluation of beef**	Beltsville, Md.	Yes	5-A-5
MQ 3-64	Verification of varietal designation of crop seed**	Beltsville, Md.	Yes	4b-A-9
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			Summary of Progress	Area and Subheading
	Foreign Agricultural Research Projects Under Section 104(a) of Public Law 480. Projects sponsored by Market Quality Research Division			
A7-AMS-6 (k)	Postharvest diseases of tropical and subtropical fruits	Allahabad, India	Yes	1-D-6
A7-AMS-12 (a)	Studies in the 'Canary Coloration' of raw wools	Delhi, India	Yes	8-A-1
A10-AMS-4 (a)	Effects of ethylene dibromide on animals	Rehovoth, Israel	Yes	4-C-5
A10-AMS-7	Development of a rapid, simple test for protein nutritive value of cereal grains and feeds		No	
A10-AMS-11	Influence of environmental conditions on khapra beetle populations	Jerusalem, Israel	Yes	4-C-1
A22-AMS-1(a)	Development of an odor-measuring instrument for use in inspection and grading of foods	Istanbul, Turkey	Yes	5-A-6
E8-AMS-1	Studies of pesticide residues	Helsinki, Finland	Yes	3-F-8 13-D-2
E8-AMS-2 (a)	Contamination of market milk by nonpathogenic bacteria		No	
E8-AMS-5	Effect of atmospheres with various concentrations of added carbon dioxide or nitrogen upon the properties of refrigerated meat	Hameenlinna, Finland	Yes	5-C-1
E-9-AMS-4(a)	Relationship between cotton fiber maturity and breakage during mechanical processing to processing performance and product quality	Rouen, France	Yes	7-A-9
E9-AMS-5 (a)	Instrument for homogenizing and orienting fibers in samples for cotton testing	Rouen, France	Yes	7-A-10
E10-AMS-3	Investigations about the antimicrobial action of biphenyl and derivatives of biphenyl on citrus spoilage organisms		No	
E15-AMS-2	Rots of apples and pears	Bologna, Italy	Yes	3-F-9
E-15-AMS-4(a)	X-ray research applied to fruit pathology		No	
E-15-AMS-8	Determination of the persistence and fate of various insecticides in or on wheat during storage, milling, and during the baking or cooking of the products made from the treated wheat		No	
E-15-AMS-9(a)	Insect infestation of spaghetti, macaroni, noodles, and other pastas	Rome, Italy	Yes	4-C-4
E15-AMS-12(k)	The effect of long term storage upon quality of edible vegetable oils	Garoglio, Italy	Yes	6-B-4
E19-AMS-8(a)	The influence of fiber length distribution on yarn quality mill processing performance	Delft, Netherlands	Yes	7-A-11
E19-AMS-11(a)	The health condition of seeds in commercial channels	Wageningen, Netherlands	Yes	4b-A-10
E21-AMS-1	Nutritional requirements of mites	Warsaw, Poland	Yes	13-A-1
E21-AMS-4	Biological control of grain moths	Poznan, Poland	Yes	13-E-4
E21-AMS-6	Influence of storage changes in flaxseed on quality of seed and properties of linseed oil	Olsztyn, Poland	Yes	6-B-1
E21-AMS-7(k)	The effect of microflora of wheat flour on its stability, biochemical and technological properties	Poznan, Poland	Yes	4-B-4
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Work & Line Project Number	Work and Line Project Titles	Work Locations During Past Year	Line Proj. Incl. in	
			Summary of Progress	Area and Subheading
E25-AMS-1	Development of objective methods for measuring market quality of raw and precooked rice	Valencia, Spain	Yes	4a-A-3
E25-AMS-5(a)	Relation of changes in the chemical and biological properties of lysozyme to changes in quality of shell eggs in cold storage*	Madrid, Spain	Yes	10-B-4
E25-AMS-6	The detection of additives in citrus juice	Valencia, Spain	Yes	1-A-3
E25-AMS-7(k)	Development and evaluation of equipment and methods for determining the proportions of durum wheat (semolina) and common wheat (farina) in macaroni and spaghetti products**		No	
E25-AMS-9	Storage changes in milled rice		No	
E29-AMS-1(a)	Apple respiration in modified atmospheres	Kent, England	Yes	3-E-2
S3-AMS-2(a)	Substrate moisture levels for germination testing of agricultural seeds	Sao Paulo, Brazil	Yes	4a-A-11
S5-AMS-3	Chemical and physiological variables of avocados and papayas	Bogota, Colombia	Yes	1-B-3
S9-AMS-6(a)	Underground storage of corn in airtight silos		No	
	*Discontinued during reporting period			
	**Initiated during reporting period			



